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IMPRIMERIE BIANCO LUNO
COPENHAGUE

Foreword.

When the International Council for the Exploration of the Sea celebrated its 25th anniversary at the Jubilee Meeting in Stockholm, the event was marked by publishing a Jubilee Volume, and the Council now in 1952 honours the event of its 50th anniversary in the same way. It is to be expected that the Governments participating in the Council and other interested parties will wish to have a report and guide to the Council's scientific work and its results during the latest 25 years in convenient summary form. For this reason the Council offers this Jubilee Volume.

The volume contains two sections. In the first part, each country presents a concentrated summary of its resources, scientists, laboratories, etc., and also its activities. In the second part, the most important subjects within the sphere of activity of the Council are reviewed in a somewhat more detailed manner.

From the summaries it will be seen, that the means of investigation during the 25-year period have been considerably increased and a strong impression is gained that the participating nations have realised more and more the necessity of carrying out, in the interest of the fishery, hydrographical-biological investigations, and further that they are animated by a wish to carry out these investigations with steadily increasing intensity.

It is also evident from the summaries that the co-operation between nations in this field has strongly developed during the period under review. This co-operation has been impressive. The Delegates and Experts of all countries have been satisfied that such collaboration is necessary, and are equally anxious that it be maintained, extended and intensified. This is gratifying and in conformity with the aims of those who took the initiative in creating our international organization.

The Council has always upheld its original intention that the main object of its activity should be the benefit of the fishery. The Council has, therefore, always endeavoured to concentrate—inter alia—on questions regarding protection of the stock of fish. In one of the contributions to the second part of this volume the matter of overfishing is also dealt with, a subject which most closely touches on practical fisheries. Here the Council has obtained very positive results, the outcome of which is a convention for the protection of fish in the North Sea and the North Atlantic.

The practice of fish marking, which has been in progress for many years and has given such splendid results, has culminated in the marking of herring, a proceeding which has already given many important and even surprising results.

Further it emerges from the review of subjects that the Council's activities have also included such important matters as predictions concerning fishery, transplantations of fish in order to improve on the stock in certain areas, and studies of plankton and of the milieu, on which all fisheries ultimately depend.

The Council should not indulge in self-praise, but I do believe that it can be said to have performed the task it has undertaken, or, at any rate, endeavoured to do so according to the available resources. Anyone who desires to examine this matter more closely is referred to the study of the Council's various series of publications.

May I be permitted to express the sincere hope that this Council may continue in future to work towards its great goal and set a good example of international understanding and co-operation.

Finally, I recall to memory the two departed Presidents of the 25-year period, Henry G. Maurice (U. K.), and Professor Johan Hjort (Norway), each of whom for many years rendered to the Council invaluable service.

K. A. Andersson.

I. SUMMARY OF THE ACTIVITIES OF THE PARTICIPATING COUNTRIES DURING THE PERIOD 1927–52

Belgique.

Dès que la Belgique devint, en 1903, membre du Conseil International, l'activité de ses représentants a cadré, selon leurs possibilités, avec les investigations scientifiques recommandées par le Conseil.

Jusqu'en 1944, elle fut l'œuvre d'un homme, G. Gilson (1859—1944). Pour collaborer aux recherches communes entreprises par les pays limitrophes de la Mer du Nord, ce travailleur acharné a dû surmonter de nombreux obstacles. Il réussit néanmoins à organiser des investigations méthodiques sur la systématique et l'éthologie de la faune des eaux côtières belges. La transformation progressive de la pêcherie littorale à voile en pêcherie à moteur retint son attention en ce qui concerne la destruction du jeune poisson par la pêche crevettière. En vue de fournir une base sérieuse à des mesures de protection, il enquêta quantitativement et qualitativement sur diverses catégories de poissons commerciaux. Réalisées sur de nombreux échantillonnages prélevés dans des conditions identiques à celles des pêcheurs crevettiers, ses observations lui permirent de démontrer l'effet désastreux de la capture d'individus de taille non commerciale sur le stock de poissons. Il préconisa une réglementation relative aux dimensions des mailles des filets ainsi que la prohibition du débarquement des jeunes poissons d'une taille inférieure à une certaine limite. Sans répit et sans ménagement, il attira l'attention des responsables sur les dangers de l'"Overfishing".

En Belgique, le hareng procure en moyenne 10 % des revenus de la pêche. Aussi, une des préoccupations essentielles de G. Gilson fut l'étude approfondie de la biologie des concentrations annuelles de ce clupéidé exploitées par les belges: harengs pleins des Smalls et du Klondyke jusqu'en 1936, harengs bouvards de la région Sandettie-Ruytingen-Dyck et harengs guais des côtes franco-belges depuis 1930—31.

Vu l'importance de l'esprot pour la petite pêcherie côtière, G. Gilson entreprit son étude depuis l'hiver 1930—31 jusqu'à l'hiver 1939—40.

De 1940 à 1948, les recherches de biologie marine connurent des fortunes diverses en Belgique. Elles se réalisent par l'intermédiaire d'une Institution d'utilité publique, dont le siège se trouve à Ostende, le "Zeewetenschappelijk Instituut" ou Institut d'Études Maritimes, grâce à l'appui de l'Administration de la Marine, Service des Pêcheries et de l'Institut Royal des Sciences Naturelles de Belgique. Des études biologiques et des expériences relatives aux filets de pêche ont pu être entreprises, à bord du "Hinders",

sur la crevette grise. Ch. Gilis, élève de G. Gilson recommença, dès 1941—42, l'étude des harengs exploités par les pêcheurs belges, celle-ci fait annuellement l'objet de diagrammes commentés établissant l'escalier biologique de ce poisson. En 1946—47, il reprit l'étude de l'esprot.

Les observations hydrographiques dévolues à la Belgique ont pu reprendre avec l'aide de la frégate garde-pêche "Lieutenant Victor Billet". Les résultats sont régulièrement transmis aux services spécialisés du Conseil International.

Les profits que les pêcheurs belges tirent de la mer justifient l'intérêt que la Belgique doit apporter aux recherches de science pure et appliquée, relatives aux questions de la biologie marine et de l'océanographie. Toutefois ce pays ne peut actuellement songer à se consacrer à des enquêtes qui réclament des moyens puissants. La Belgique apporte sa participation sincère aux recherches préconisées par le Conseil International.

E. Leloup.

Denmark.

During the past 25 years working conditions for Danish fishery research work have greatly improved, both as regards research vessels, laboratory and aquaria conditions and the number of those employed by the institution.

Inside the Skaw there have been routine investigations concerning the economically important species (designed to control stock fluctuations) such as plaice, flounder, dab, cod, herring etc. Research on shellfish such as Norway lobster and deep sea prawn (*Nephrops* and *Pandalus*) has also led to a thorough knowledge of these new subjects. In addition to the plaice transplantations carried out for many years in the Limfjord, Dr. A. C. Johansen began in 1928 comprehensive transplantations to inner Danish waters, the live plaice being transported from the North Sea by lorry from Esbjerg to Fredericia. This attempt to increase the gradually failing plaice stock in, *inter alia*, the Belt Sea was continued by Dr. H. Blegvad.

In addition certain international measures of protection of flatfish were obtained, through the agency of the International Council, for the Baltic area and, for shellfish, in the Kattegat-Skagerak area. Furthermore comprehensive investigations have been carried out in many special spheres, such as, for example, concerning markings of herring, evaluations of the animal communities of the sea bottom of the Kattegat and Limfjord, concerning the Zostera disease, and the contamination of the Sound and various fjords, the immigration of more or less rare species of fish etc. Predictions concerning eel and mackerel fishery have by degrees become a development of importance.

The **North Sea Area** has been more important than during the first decades of the century. Plaice research work has been particularly significant. Stock analyses, partly in coastal districts and partly in the open North Sea, are still carried out. An attempt by Dr. A. C. Johansen to persuade the countries bordering the North Sea to take part in a united action to transplant plaice to the Dogger Bank as proposed by Prof. W. Garstang 1905, came to naught, as plaice fishery in the Dogger area gradually became

mainly the concern of Danish cutters. Then in not only 1949 but also 1950 a Danish experimental transplantation of about one million young plaice from coastal districts (Grådyb and Thyborøn areas) was carried out. The most satisfactory method proved to be for well boats to catch the fish in the Grådyb area and sail direct to the Dogger Bank.

Increasing Danish interest in North Sea herring fishery has led to Danish research into Fladen Ground herring. Marking has confirmed A. C. Johansen's theory that North Sea bank herrings migrate to the Skagerak during the winter.

For a number of years Danish hydrographic cross-sections of the central area of the North Sea have been made generally in May.

The **Faroe Area** has seen investigations on the cod, halibut and herring. Cod-marking has thrown light on the movements of adult cod in the Faroe area. The marking of halibut has shown that young, not yet sexually mature, halibut migrate as far as Iceland or into the North Sea. Attention has in particular been directed to the occurrence of herring to the north and north-east of the Faroes, in the area of the east Iceland current's so-called "cold tongue".

Denmark's contribution to the investigation of the **Iceland Area** has been concentrated on cod and herring migration, attempts to secure nursery areas for plaice, halibut, haddock etc. in Faxa Bay, and study of climatic changes.

Cod-marking off West and East Greenland and off Iceland has confirmed the periodic movements of enormous numbers of cod between the Greenland and Iceland areas, and *vice versa*. In the area between the Faroes, Iceland, Greenland, the Labrador Current and the Gulf Stream, year-long research of a hydrographic-biological nature has been carried out, *inter alia*, to fix the breeding area of the redfish (*Sebastes*).

The **Greenland Area** has been studied with particular regard to the Davis Strait. The increasingly prolific cod stock has been studied by Dr. P. M. Hansen and stock analyses have been carried out since 1924. Only a few year-classes of cod during this period have been outstanding and they occurred when temperatures on the breeding banks were highest. Comprehensive markings have also been carried out, of cod, Greenland halibut, Greenland shark etc. Rich shrimp banks (*Pandalus borealis*) have been discovered. The influence of the important climatic changes on marine life and its outstanding importance was first demonstrated in Greenland and Iceland waters (by Ad. S. Jensen and Bjarni Sæmundsson). During the past 15—20 years this study has continued. In the North Atlantic area numerous hydrographic and planktonic investigations have been carried out, *inter alia* in connection with the study of climatic changes.

During the period J. P. Jacobsen put forward his proposal regarding the use of T S diagrams (1929) and E. Steemann Nielsen carried out investigations concerning the plankton production.

Johs. Schmidt's circumnavigation of the world (1928—30) also took place, financed by the Carlsberg Foundation. Among the main objectives of this expedition was a general investigation of the breeding places of the freshwater eels in all oceans, an undertaking which was carried out with success.

During 1940—1952 the racial investigations begun by Schmidt were resumed.

Å. Vedel Tåning.

Finland.

The physico-chemical branch of marine research work is conducted in Finland at the State "Institute of Marine Research" (Fi.: Merentutkimuslaitos, Sw.: Havsforskningsinstitutet), the fishery-biological branch at the State institution "Bureau for Fishery Investigations" (Fi.: Kalataloudellinen Tutkimuslaitos, Sw.: Lantbruksstyrelsens Fiskerihushållningsbyrå) and at "The Biological Commission" of the Finnish Society of Sciences. Both branches are represented in the Council.

Hydrographical observations are regularly undertaken at a great number of coastal stations and at lightships. Readings are obtained of surface and depth temperatures, salinities and currents, winds, sea level and ice conditions. Up to the War more extensive investigations in the Northern Baltic were made each summer during special cruises by a research ship. Sometimes surface observations have been made on board Baltic liners. In addition some special investigations have been carried out in the Archipelago.

The marine-biological observations have been more sporadic.

The readings mentioned above have been published, or are about to be published. Their scientific working up comprises the main part of the work. Thereby practically important questions have often taken the foremost place.

Among these the study of the ice comes first of all, because the knowledge of the ice conditions in the Baltic is vital for the whole Finnish winter navigation. The Institute took an active part in the formation of the international ice and navigation codes, and it has, using its own Radio station, charge of the daily ice reporting.

Numerous investigations deal with the analysis of the severe winters and the course of a "normal" one, the growth, the quality and the thickness of different kinds of ice, and the maximum area covered by them. Attempts at ice prognostication have been made. The investigations have been illustrated by synoptical ice maps, diagrams and statistical tables and put in connexion with the warmth in the sea, currents and different hydrographical and meteorological elements.

The regular temperature and salinity readings have been harmonically analysed and the actual increase of the salinity in the Baltic investigated, new tidal constants fixed (also in connection with Petsamo which later came to an end) and practical tables of the variations of the sea level worked out. The connexion between wind, currents, inclinations of the sea level, and the water layers has been studied, further the practically important upheavel of the coast. The Institute introduced echo soundings in Finland, preparing a new bottom map of the Bothnian Bay. Mention must also be made of theoretical investigations about oscillations in a limited sea area, and about penetration of light into the sea.

Experimentally and theoretically the equilibrium system between carbon dioxide, excess base and pH has been worked out at different temperatures and salinities, and applicated for examining the carbon dioxide exchange with the atmosphere, the calcium

carbonate saturation and generally for determination of the carbonic and constituents and their correlation to the biological activity.

Studies have also been made on bottom sediments of the Baltic, special works on mechanical analysis and determination of traces of heavy metals in sea water by means of dithizone.

The biological investigations are foremost dealing with plankton and the life in the coastal waters and, in regard to the sea fisheries, mainly with salmon and herring.

Nutrient salt methods have been worked out and used to explain the general biochemical circulation in the Baltic.

Finally reference must be made to a contribution to the question of the equatorial counter current and a biochemical investigation made in the sea off Petsamo and Icelandic waters on board a fishing ship.

GUNNAR GRANQVIST.

France.

Depuis son adhésion, en 1920, la France a régulièrement apporté sa contribution aux travaux du Conseil International.

Travaux à la Mer. Les travaux à la mer on été poursuivis à bord des navires spécialement armés: "Perche", "Tanche" et (depuis 1933) "Président Théodore Tissier".

Les avisos de la Marine Nationale (chargés de la protection et de la surveillance de la pêche): "Pourquoi-Pas", "Estafette", "Sentinelle", "Ville d'Ys", "Aventure"; les vedettes de la Marine Marchande, la "Sainte Jeanne d'Arc" et de nombreux bateaux de pêche ont participé à ces travaux dans une vaste zone s'étendant de la Mer de Barentz et l'Islande, jusqu'au Groënland, Terre-Neuve, les Antilles, les Açores, les îles du Cap Vert et le Sierra Leone, au sud, puis, en Méditerranée occidentale.

Des cartes de pêches avec isobathes ont été établies pour la Mer du Nord, la Manche, la Mer Celtique, le Golfe de Gascogne, les côtes d'Algérie et de Tunisie, la région de Terre-Neuve et du Groënland, la Mauritanie et le Sénégal.

De nombreux dragages géologiques sur le plateau continental eurafricain ont permis de compléter les connaissances acquises sur la géologie sous-marine. (Travaux de DANGEARD, BEAUGÉ, FURNESTIN, BERTHOIS, BOURCART).

Les conditions hydrologiques (t° et $S^0/_{00}$) à diverses profondeurs ont été régulièrement publiées. Ces travaux ont permis à LE DANOIS d'établir sa "Théorie des Transgressions atlantiques", hypothèse de travail toujours discutée, mais qui a servi de base à de nombreux travaux sur le comportement des espèces marines.

Biologie des Espèces Marines Comestibles. Clupéidés. — Depuis 1925, les recherches poursuivies par l'Office Scientifique et Technique des Pêches Maritimes, appliquant les techniques internationales, ont donné lieu à d'importants travaux publiés sur:

— le Hareng des Fladens, de la Mer du Nord, de la Manche, des Smalls et du Klondyke irlandais (Travaux de LE GALL, puis ANCELLIN);
— le Sprat des côtes françaises (LE GALL, FAURE, FOREST, FURNESTIN);

— la Sardine des côtes atlantique et méditerranéenne (le Gall, Desbrosses, Belloc, Furnestin, Letaconnoux);
— l'Anchois (Furnestin, Forest).

Depuis 1949, des expériences de marquage ont été faites sur le Hareng et la Sardine (6,000 poissons marqués).

Gadidés. — Travaux de Belloc, Letaconnoux, Furnestin, Maurin, Cadenat, Heldt, sur le Merlu. Importants travaux de Beaugé et le Danois sur la Morue de Terre-Neuve et du Groënland. (Définition des Eaux de Morue. Fluctuations de la pêche).

Recherches sur le Merlan (Desbrosses).

Scombridés. — Travaux de le Gall sur les concentrations de Maquereaux sur le Plateau Continental Celte, continués par Nedelec. Études régulièrement suivies sur la biologie du Germon ou Thon blanc en Atlantique et sur celle du Thon rouge en Méditerranée. Définition des "Eaux à Thons", recherches des frayères de l'espèce. Étude générale des Thonidés de l'Atlantique Est (Travaux de le Danois, Belloc, le Gall, Legendre, Heldt, Dieuzeide, Postel, Priol).

Poissons divers. — Recherches sur les Dorades, le Rouget barbet, le Saint-Pierre ou Jean Doré (Desbrosses, Fage), les Scorpaenidés et poissons de la côte occidentale d'Afrique (Cadenat); la Cardine (Furnestin), les Mugilidés (Arné).

Biologie des Mollusques et des Crustacés. Études régulièrement poursuivies ayant fait l'objet de nombreuses publications (Boury, Bouxin, Dalmon, Desbrosses, Ranson, Lambert et ses collaborateurs).

La faune du fond et le plancton ont été régulièrement étudiés et ont donné lieu à diverses publications.

J. le Gall.

Iceland.

Prior to 1931 there was no provision in Iceland for marine or freshwater research. On 1. January of that year the Fisheries Association of Iceland (Fiskifélag Islands) appointed a fisheries biologist. Some limited facilities to carry out marine-biological work were available. In 1937 Iceland became a member of ICES, and in September of that year, the University Research Institute (Atvinnudeild Háskólans) was founded. The Fisheries Department (Fiskideild) of that institute then took over all fisheries research. The advisor of the Fisheries Association was appointed as head of the department and the appointment of advisor to the association was cancelled.

With the opening of the University Research Institute working facilites were greatly improved. During the next 12 years the department expanded considerably and is still expanding. Four years ago it therefore became necessary to rent a flat in a new building and move the laboratories. As a final stage in the development, a new institution is now under construction, and will probably be ready for use in 2 or 3 years. This institution will be devoted exclusively to the fishing industry, being subdivided into a technical and a biological department. On Siglufjord, in the north, a laboratory is in operation for herring research during the summer months. A research boat (M/S "Maria Julia"), about 85 feet, is now available, but is partly used for fishery inspection and life-saving service. Every year one or more vessels are chartered for cruises, herring tagging, etc.

During 1931—37 only the scientific advisor of the Fisheries Association was in charge of research work. But since the opening of the University Research Institute the staff has grown from 2 scientists and 4 assistants, as it was during the first years, to 5 scientists and 9 assistants, as it is now. During the summer months, 4—6 additional assistants are engaged.

Regular hydrographical service is now carried out all around Iceland and in off-shore waters in collaboration with foreign scientists. The endeavour is to find hydrographical-biological correlations of importance for the fisheries and to follow the strength and extent of the principal ocean-currents from time to time. Drift-bottles, thermographs, and bathy-thermographs are in use.

Plankton work is now mainly concentrated on the distribution of fish larvae in order to find the time and place of principal spawnings from year to year. Invertebrate zooplankton and phytoplankton has also been dealt with.

A particular effort is being made to investigate some of the most important food-fishes, especially herring and cod, where large-scale taggings, stock analyses and racial investigations (herring) are carried out. In Iceland tagging of herring began in 1948. Other food-fishes, such as saithe, haddock, redfish, halibut, plaice, and salmon have also been dealt with. The main features of these investigations are:—fluctuations, rate of mortality, and migrations of the principal stocks. In the case of cod and herring considerable results are already on record. This applies particularly to the migrations of the herring, the recent knowledge of which promises to be of great benefit to the fishery.

Árni Friðriksson.

Ireland.

Ireland's contribution since 1925 towards the programme of the International Council, as far as marine research is concerned, in the main depended on the energies of the late G. P. Farran, who, until he retired from office with the Department of Agriculture, Fisheries Branch, Dublin, in 1946, was responsible for marine research in this country. Farran organised quarterly cruises on either the south or north coast of Ireland when temperatures were taken at different depths, together with associated salinity and plankton samples. These quarterly scientific cruises from 1925 until 1939 covered areas for which there were few other data. Sea surface temperatures have also been recorded almost continuously since 1925 to date from the Conigsbeg Lightship and Farran, himself, recorded the variations at this station in a paper published in 1939 in the *Rapports et Procès-Verbaux* (Vol. CXI).

Work on plankton by Farran with various collaborators resulted in a number of published works from his pen and later from that of Dr. W. E. Frost devoted mainly to Copepods and Euphausids. Ireland took part in the special mackerel investigations started in 1938 when British, French and Irish research vessels made simultaneous observations over the seas south of Ireland, to ascertain the spawning areas for mackerel. A number of papers by Farran on the herring were published in the *Journal du Conseil*, *Rapports et Procès-Verbaux*, and in the Journal of the Department of Agriculture, Dublin. In recent years this aspect of research work in Ireland has not been given the same attention as heretofore.

Since the end of the war, work has started on the life history, growth, sexual development etc. of sprats and escallops around the Irish coasts and, while fairly extensive material has been collected, it has not been found possible as yet to put this into a suitable form for publication.

After the First World War more attention was devoted in Ireland to freshwater fishes and, in particular, to the salmon which is the most important fish in the economy of the country. In 1928 Southern published the results of the first systematic study of the life history of the salmon of an Irish river. He also started the series of investigations now known as the "River Liffey Survey" in collaboration with Dr. W. E. Frost who took over responsibility for this work after Southern's death.

Investigations into the age and growth of Irish salmon have been continued in recent years by A. E. J. Went and a number of reports have been published on this aspect of fishery research in Ireland. A number of investigations have also been made into the life history of Irish sea trout. Since the end of the war a considerable amount of attention has been devoted to the movements of salmon around the coasts of Ireland. Tagging operations were carried out in the years from 1948 onwards at five centres along the coast of the Republic. From 1950 onwards, in collaboration with the Ministry of Commerce, Belfast, several tagging stations have been operated along the coasts of Co. Antrim. From these experiments it is obvious that there are extensive movements of salmon around the Irish coasts which were formerly unsuspected.

A. E. J. Went.

Netherlands.

Before the 1939—1945 war the Dutch investigations on sea fisheries had to be carried out without the help of a fishery research vessel. Occasional use could be made of a fishery patrol vessel. One biologist, Dr. J. J. Tesch, was in charge of the investigations. He did much work on the herring of the southern North Sea and the eastern Channel.

The ages of great numbers of herrings from the commercial drift-net catches were determined. The results of these investigations were used in each year for the prediction of the size and composition of the catches in the next year.

Much work was also done on the races of the herring in the southern North Sea. These investigations were not restricted to the mature fish, but included the identification of the young herrings occurring in enormous shoals in the Dutch estuaries and inlets. The number of vertebrae of larvae was also determined. The results of the investigations were published in the periodicals of the International Council.

Another topic was the quantitative distribution of year-classes of plaice along the Dutch coast. These investigations were carried out on board the fishery patrol vessel "Nautilus". The material was collected by experimental fishing on 18 stations on 4 sections from the coast between Ameland and IJmuiden. The work was continued from 1933 until the outbreak of the war. In the years about 1928 the savings trawl was expected to be of great importance for the protection of young flatfishes. Special attention was paid to a Dutch type of this kind of gear, known as the Gelder trawl.

During the war, work at sea was impossible: activity was restricted to the studies of literature and theoretical subjects (G. P. Baerends on rational fishing in the North Sea). After the war, investigations were begun on the growth of plaice by means of otoliths with the object *inter alia* of back calculating the growth of plaice during the war.

Comparative fishing experiments were carried out on board of commercial fishing vessels and in cooperation with the English research vessel "Platessa".

Since 1946 the landing statistics of the trawlers have been worked up by the statistical rectangles of the North Sea in order to be able to follow the density of the commercial fish stocks.

In 1949 a fishery research vessel, "Antoni van Leeuwenhoek", started work. One of the main investigations is the quantitative study of the plaice in the Southern Bight in close cooperation with the English scientists at Lowestoft. In addition, the ship is used for investigations of the gear and of the detection of fish shoals by means of echo-sounders.

Since 1947 herring charts have been composed from the data in the log-books of the herring luggers and from the landing statistics of the herring trawlers. In 1950 investigations commenced on the vertical and horizontal movements of the herring shoals. Age, race and stomach contents of drift-net and trawl herring are being studied.

Hydrographical work included observations of salinity and temperature of surface water from lightships and steamer routes, and sometimes on lines in connection with international series of cruises. Since 1937 current measurements have been carried out on board lightships.

G. J. Lienesch.

Norway.

In the years around 1927, Norwegian fisheries investigations were operated under difficult conditions. The staff was small, and the means available were only sufficient to enable contact to be maintained with the commercially most important fish stocks.

The research vessel "Michael Sars" had been taken over by the Royal Norwegian Navy during the 1914—18 war. To replace it, a small vessel, "Johan Hjort", of about 70′ was built in 1922. With the aid of this and hired vessels, regular annual investigations were carried out in coastal waters and in the North Sea, the Norwegian Sea, the Bear Island and Spitsbergen areas, the Barents Sea and also in more distant waters. On these cruises, hydrographical and biological work was undertaken as well as practical fishing experiments.

Important observations on the geographical distribution of the Arctic cod were made on cruises to northern waters in the years from 1923 to 1940. It was found that the cod, in the late twenties, advanced as far north as the waters around Bear Island and off West Spitsbergen, and this discovery gave rise to rich fisheries in these areas.

In the years 1930—35, a number of new research problems were taken up. The hydrographical work was extended; age determination of cod was initiated with improved methods. Increases in the staff from 10 to 18 members, and financial support from the Fishing Industry Research Fund, made possible the carrying out of special investigations on race and stock, marking experiments, and experiments on hatching, breeding and hybridizing of salt water fish.

In 1935, R/V "Johan Hjort" was equipped with an echo-sounding gear, and the obvious advantage of the echo-sounders in the herring and cod fisheries was demonstrated. With echo-sounders, it was also found possible to locate and outline the type of bottom preferred by the deep sea prawn.

During the second world war, the research programme was very restricted, especially as regards cruises. The work was concentrated on collecting the necessary material for the biological statistics.

Since 1945, the Norwegian fisheries investigations have been going through a period of expansion. In 1947, the scientific marine research work of the Directorate of Fisheries was reorganized, a director being appointed to be in charge of an institute of more independent status. In 1950, a new seagoing research vessel, "G. O. Sars", was commissioned. The staff increased to 40 members.

Fisheries investigations were started in West Greenland waters in 1948. In the summer of 1949, special herring investigations were begun in the Norwegian Sea with a hired vessel. From 1950, when the R/V "G. O. Sars" was put into commission, it has also been possible to undertake winter cruises. On the latter cruises, the shoals of herring have been followed on their migrations from the Norwegian Sea to the west coast of Norway, and on the summer cruises it has been possible to locate the feeding areas of the herring in the Norwegian Sea. On all cruises, extensive hydrographical material has been collected.

G. Rollefsen.

Portugal.

Hydrologie. — Une série de croisières océanographiques avec le bateau de recherches "Albacora" en vue de la connaissance des conditions hydrologiques au large de la côte du Portugal, ses variations annuelles et saisonnières. Ces croisières ont été prolongées, en 1927—1929 jusqu'à la région du Golfe de Gibraltar et au Détroit du même nom, pour l'étude de la distribution des eaux profondes d'origine méditerranéenne. Une croisière a été effectuée en 1930 s'étendant jusqu'aux îles Canaries et Madère, en vue de collaborer avec les recherches du bateau norvégien "Armauer Hansen". L'"Albacora" ayant été désarmé en 1941 et n'ayant pas été substitué, les recherches en mer ont été interrompus.

Biologie. — La sardine a été étudiée plus particulièrement au point de vue de la biométrie des populations pêchées au large du Portugal, de Madère et des Azores, des aires et des époques de ponte, de l'évolution de la maturité sexuelle au cours de l'année, de la croissance, de la variation saisonnière du poids moyen, etc. Depuis 1947, après la rentrée du Portugal au Conseil, ces études sur la sardine ont été repris avec plus de régularité, en liaison plus étroite avec les travaux du même ordre des services français et espagnols.

Des travaux sur les thons, commencés en 1924 par M. Frade et ses collaborateurs, ont été poursuivis depuis 1927; ils ont porté sur la morphologie, la biométrie et la systématique des espèces atlantiques (européennes et africaines) et leur comparaison avec les espèces du Japon qui avaient été étudiées très complètement par Kishinouye (1923). Frade est arrivé à éclaircir le problème de la définition et de l'identification des deux espèces décrites sommairement par Lowe en 1839 dans les eaux de Madère, c'est-à-dire, *Neothunnus albacora* et *Parathunnus obesus*, mais dont les naturalistes n'en faisaient souvent mention, parceque mal connues. Frade a aussi étudié le processus de la maturation sexuelle des ovaires de *Thunnus thynnus*. Des essais de marquage du thon, pour l'étude des migrations, ont été aussi entrepris en Algarve (côte méridionale du Portugal) en 1932—1933 et 1935—1938.

La biologie de la palourde (*Tapes decussatus*) a été étudié par M. Vilela (1938—1951), particulièrement au point de vue de l'évolution de la maturation sexuelle au long de l'année, de la croissance, et de l'écologie en général.

Le Plancton a été l'objet de recherches préliminaires (faunistiques et quantitatives), d'abord par M. Candeias (depuis 1926) qui ont compris les Schizopodes, Copépodes, Ciliés, Dinoflagellés, Diatomées, etc. Plus récemment, des observations du même ordre ont été faites par Mme Sousa e Silva et M. Pinto (1948).

Statistique des Pêches. — En vue d'améliorer la notation des données permettant une connaissance plus complète de l'influence de la pêche sur les stocks de poissons exploités, depuis 1934 on demande aux patrons des bateaux de pêche des renseignements sur l'effort appliqué (nombre des coups de chalut, heures de pêche, etc.).

A. M. Ramalho.

Spain.

The "Instituto Español de Oceanografia" has continued its oceanographical work and research between 1927 and 1952, but, since 1936, this has been very limited on account of the Civil War and later the World War. Nevertheless, it has endeavoured to continue the programme recommended by the International Council, concerned mainly with the Cantabrico Sea between latitude 43° N. and longitude 4° W. and the Straits of Gibraltar, especially the eastern mouth of the Straits and the Alboran Sea.

As regards publications, the *Boletin del Instituto* has taken the place of the former *Notas y Resúmenes*, while the publication of *Trabajos* has continued.

Some research has been carried out in the Saharian waters resulting in the production of the fishing charts Cabo Ghir to Cabo Barbas.

Work is now proceeding on the outlining of the charts Cabo del Agua to Punta Malabata off the Spanish Protectorate of Morocco.

Besides the main laboratories at Madrid, the "Instituto Español de Oceanografia" has established coastal stations at San Sebastián, Santander, Vigo, Málaga, and Palma de Mallorca and another is now under construction at Santa Cruz de Tenerife (Canarias).

Two vessels, "Xauen" and "Arcila", formerly Navy coast-guard ships, have been adequately adapted for oceanographical purposes.

The "Xauen" operates in the Cantabrico Sea and waters to the north-west of the peninsula, while the "Arcila" has been designed to work in waters to the south-west of the peninsula, the West African region from Cabo Espartel to Galgo Bay, the Gibraltar Straits and Spanish Mediterranean Sea (including the Balearic Islands) and the Mediterranean off the Spanish Protectorate of Morocco.

Under the new organization of the Institute, the scientific staff includes biologists, physicists and chemists distributed among four sections: Marine biology, Oceanographical physics, Marine physico-chemistry and Industrial chemistry. The work of these sections includes, besides the normal work of the coastal laboratories:—

the drawing of fishing charts of Spanish and African waters,
the study of the main species of fishes, molluscs and shellfish,
the methodic study of plankton,
researches on pisciculture,
the study of tides and surface and bottom currents in Spanish waters,
researches on the capture and conservation of marine animals, and on the utilization of fishery by-products,
the study of net preservatives and the corrosion and fouling on fishing vessels,
researches on new fishing techniques.

The "Instituto Español de Oceanografia" has endeavoured to proceed in accordance with the decisions and suggestions of the International Council, and is honoured to form part of that organization which, due to its long life and scientific experience, is considered as the most important body among those engaged in marine research throughout the world.

Garcia Rodriguez.

Sweden.

Biology. Numerous expeditions have been made by the research vessels "Skagerak" and "Eystrasalt" to all parts of the Baltic, to the Kattegat, Skagerak and the North Sea and to the Atlantic north and west of the Shetland Islands and west of the Hebrides.

Much work has been done to distinguish between the different herring populations occurring both along and off the entire coast of Sweden. The fluctuations in the year-classes of the herring have been studied in detail and the dependence of the fishing industry on these has been demonstrated.

Close studies of the structure of the scales have shown that the bulk of the herring caught during the winter in the eastern Skagerak are identical with the type caught during August and September in the north-west part of the North Sea (Fladen Ground). To confirm this theory with tangible evidence it became essential to tag the herring. The tagging experiments were first carried out with Einar Lea's hydrostatic tag on the west coast of Sweden in 1949 and were continued in 1950 and 1951. These experiments showed that the Skagerak winter herring migrated to the western North Sea, thus confirming the result obtained by the scale investigations.

The herring investigations in the Baltic have shown how a very abundant year-class, that of 1937, gave rise to an unusually successful herring fishery during the whole of World War II.

The great fluctuations in the occurrence of sprat have been found to be correlated with certain hydrographical and meteorological conditions.

Owing to great variations in its hydrographical conditions the Baltic offers much of interest. During the 1930's and 1940's a considerable increase in the salinity caused an enormous rise in the cod fishery.

Great fluctuations in the abundance of the first year-class of haddock with consequent fluctuations in the fishery have been demonstrated.

The flatfishes have been the object of comprehensive investigations in the various areas. In the southern Baltic the overfishing problem was considered, and a great depletion of the stocks with a simultaneous increase in the rate of growth was revealed.

The eel and the salmon have also been the object of considerable research, particularly in the Baltic. These species, especially salmon in large numbers in the Norrland rivers, have been tagged.

Plankton research has been carried out especially in the Baltic on macroplankton.

Hydrography. In addition (a) to the hydrographical studies carried out in connection with the biological investigations, the regular collection of hydrographical data, and (b) to the participation in the international North Sea investigation 1948—1950, a number of problems falling under physical oceanography have been studied. Thus, considerable attention has been paid to the internal movements and the semidiurnal internal waves discovered by Otto Pettersson, the inertia currents in the Baltic, radium and uranium in sea water, the optical properties of sea water and the penetration of daylight into the sea, and the sediments on the shelf and in the deep-sea.

K. A. Andersson. B. Kullenberg.

The United Kingdom.

Between 1927 and 1939, the main fishery research of the United Kingdom under the Council originated from the laboratories at Lowestoft and Aberdeen, which together housed a staff of a little under thirty scientists. The sea investigations depended mainly upon two steam trawlers, the "Explorer" and the "George Bligh"; which investigated an area between the Faroes and the S.W. of Ireland, but were more particularly occupied in the North Sea. At the same time marine research with applications in fisheries was being undertaken at Plymouth, Millport, Cullercoats, and Port Erin.

Of first importance among the fish species studied were the herring, plaice and haddock. Secondary investigations concerned the cod, hake, pilchard, sprat, lemon sole, salmon and shellfish. Established hydrographic and plankton lines were operated annually in the Faroe-Shetland Channel; more frequently there were the observations of research vessels in the North Sea; and regular observations from lightships. Routine surveys of the North Sea by continuous plankton recorders were operated from Hull and Leith, and extended to Iceland.

Statistics of demersal fish, collected at the ports, and referred to "statistical rectangles", were based on single voyage reports giving origin, effort, and categories in respect of the weight of catch landed. Fish measuring was carried out at the ports, and at sea on commercial vessels. Experimental fishing, particularly with different sizes of mesh, was undertaken.

After the war, the fisheries staffs were re-constituted, and now include between fifty and sixty scientists. There are four large steam vessels, three of them trawlers, of which only one (the "Explorer") is a pre-war ship, and four smaller motor-vessels. The distant water range has been extended to Iceland and the Barents Sea. Fundamental marine biology has also been extended by means of increased staffs at the laboratories mentioned above.

The cod of the Barents Sea area has become a major object of research. In addition the herring has become the object of team work devoted to understanding its shoaling behaviour, particularly in relation to feeding. The use of the echometer for location and of new methods of tagging herring have been features of this herring work, and detailed port landing statistics are now being obtained. Other species investigated include haddock, sprat, pilchard, whiting, sole, halibut and the lobster, whilst work on salmon and trout in rivers has been developed.

Work designed to determine the relative fishing value of different types of fishing vessels, of gear and of modifications of gear, and of different sizes of mesh has involved fishing in company with commercial vessels of the United Kingdom and with those of other nations. Detailed studies of the modes of operation of different gears are being made.

Hydrographic and plankton observations have been continued in the North Sea and Faroe-Shetland Channel, and in addition regular lines of stations have been made west and south of Bear Island. Continuous plankton recording in the North Sea has been resumed, and extended over the north-eastern Atlantic Ocean by the use of Weather Ships, which are also providing other valuable observations.

1.

The Milieu.

By HELGE THOMSEN

FROM the very beginning the study of the milieu has constituted an important part of the Council's activities. Reading the "Projet de Programme" annexed to the invitation of the Swedish Government to the Conference in Stockholm 1899, one gets the impression that the obvious advantages of international co-operation in the study of the milieu was a main reason for the formation of the International Council. The word "milieu" was not used, but it covers the sort of hydrographical investigations recommended, which should aim at throwing light on the behaviour of fish.

"Milieu", interpreted in a broader sense, would include, besides the properties of the water itself, the properties of the bottom with its fauna and flora, and also of the plants and animals living in the water. Here "milieu" will be used in a more restricted sense, comprising only such features of the chemical and physical properties of the sea which are known or believed to be of significance for life in the sea, or in other words, that part of hydrography which is now often called fishery-hydrography. One very important side of this field, namely that of the cycle of nutrient salts and the carbon-dioxide equilibrium will, however, be reviewed elsewhere.

On the following pages I shall attempt therefore to review only the major results obtained during the last 25 years in the study of the distribution of temperature, salinity and oxygen contents and the fluctuations of these quantities, together with the study of currents and submarine illumination.

At the reorganization of the Council's work in 1925 a number of Area Committees were established which were, i. a., charged with the task of formulating and putting into effect, within the areas, programmes for the study of hydrographical conditions which affect the life and movements of the fishes.

A special Hydrographical Committee was also established and charged with the treatment of hydrographical questions on a general basis; this committee was for 22 years under the chairmanship of MARTIN KNUDSEN. This division of the Council's activities within the field of hydrography has been maintained throughout the past 25 years. The Service Hydrographique has as hitherto been charged with the publication of hydrographical observations in the *Bulletin Hydrographique*, which since 1937, however, has not contained current measurements. A re-arrangement of the data was performed in 1932 since when the data have been arranged according to one-degree squares, which has made it easier for users to find the data originating from a certain area. Routine observations from coastal stations and lightships have generally not been included in the Bulletin. Such observations have been published currently by national institutions in Denmark, Finland, Germany and Sweden. On the initiative of the late Captain NELLEMOSE, a card-index was founded, which now contains all published observations of temperature and salinity within the Council's area north of the Equator and from which abstracts may be obtained on request. Since the edition of the *Annales Biologiques* began, this publication has contained short surveys of the hydrographical conditions in the different areas.

The methods employed in investigating temperature, salinity, oxygen and currents have largely been the classical ones, though the field work has been greatly facilitated by the use of echo-sounding gear, which has steadily been improved. Two new instruments for the continuous recording of subsurface temperatures should be mentioned, namely the Bathythermograph designed by SPILHAUS and the Thermosonde by MOSBY. The former can be worked from a moving ship, but its application is limited to relatively small depths. The latter can be used to any depth, but only when the ship is stopped.

Various new current meters have been constructed

among which may be mentioned the Vertical Log designed by CARRUTHERS, which has the advantage of great sturdiness and simplicity, and has been used for continuous current measurements, especially from lightships in the North Sea. Another current meter which has been constructed and used in recent years is the German paddle-wheel current meter, which can be moored and left unattended and is able to record the direction and speed of the current at 5-minute intervals during a period of 4 weeks.

Several new handbooks on oceanography have appeared. The most comprehensive one is "The Oceans" by H. U. SVERDRUP, M. W. JOHNSON and R. H. FLEMING (1942), well known to all workers in oceanography. Other handbooks have been edited by A. BERGET (1930), A. DEFANT (1929), G. H. FOWLER and E. J. ALLEN (1928), H. W. HARVEY (1928, 1945), J. JOHNSTON (1928), H. A. MARMER (1930), J. ROUCH (1943), F. S. RUSSELL and C. M. YONGE (1928).

An understanding of changes of the milieu within the borders of the Council's field of operation presupposes knowledge of the hydrography of the Atlantic Ocean because all the various areas constitute a part of or are connected with that ocean. During the past 25 years our knowledge of the hydrography of the Atlantic Ocean has been increased considerably. J. P. JACOBSEN (1929) used t-S-diagrams for a study of the water masses of the North Atlantic, based on the observations from the "Dana" Expedition 1921—1922 together with other observations then available. This method has proved to be of great value in distinguishing the different characteristic water-masses and the study of their propagation and mixing.

Another important contribution to the hydrography of the North Atlantic was given by B. HELLAND-HANSEN (1930), who worked up the observations from the "Michael Sars" Expedition and—although as a detail in the whole work only—discussed the problem of the annual temperature cycle in the deep.

In the thirties the reports on the "Meteor" Expedition 1925—27 began to appear. Although the southern and equatorial part of the Atlantic was the working field of this expedition, the existing observations from the North Atlantic were included in the scientific treatment. In 1936 G. BÖHNECKE's treatment of the temperature, salinity and density of the surface water was published, and in the same year G. WÜST's and A. DEFANT's treatment of the corresponding subsurface observations appeared. Both these reports were accompanied by the well-known beautiful atlases of temperature, salinity and density, the former with monthly charts, and the latter with horizontal charts for different levels from 200 m. to the bottom.

A. SCHUMACHER (1940) published new current charts for the North Atlantic based on the observed "sets" of ships. On 12 charts, one for each month, he gave a representation of the mean direction and velocity of the current together with an indication of the persistency. A new edition (3rd) of G. SCHOTT: *Geographie des Atlantischen Ozeans* appeared in 1942.

As in the past, the Gulf Stream has in the last 25 years attracted the attention of many scientists, not least on the western side of the Atlantic, where the efforts culminated in the great "Operation Cabot" in 1950. During 17 days 6 ships under the direction of R. H. FLEMING worked hydrographical sections across the Gulf Stream between Cape Hatteras and Long. 50° W. In this way it was possible for the first time to draw synoptic charts day by day over the course of the stream. It transpired that the stream incessantly shifted its course, winding like a serpent, and the gradual development of a meander into an eddy on the south side of the stream was observed. The existence of such great eddies had already been established by investigations from "Atlantis" but here, so to speak, the creation of an eddy was witnessed.

Great investigations of the Gulf Stream have also been carried out further east. In May—July 1938 6 countries with 7 ships co-operated in a research programme worked out by an international committee under the chairmanship of B. HELLAND-HANSEN. The most intensive investigations were made in the area north-west of the Azores, where observations of temperature and salinity were made together with current measurements from an anchored ship. Investigations in the Norwegian Sea had revealed great variations in space and time of the course of the Atlantic Current. The spacing of the stations was therefore made very narrow and revealed a very complicated course of the Gulf Stream which, in this place, was split into three branches. Another characteristic feature which was again observed here was the astonishing effect of the shape of the bottom on the hydrography of the surface layer, even when the depth was measured in thousands of metres.

The problems connected with the Gulf Stream have become especially important in recent years since a rise of the mean air temperature has been observed in northern Europe (R. SCHERHAG, 1936) together with a corresponding rise of the sea temperature. This phenomenon, which was the object of a special scientific meeting in 1948, has been examined by many scientists on the basis of meteorological, oceanographical and glaciological observations. The change of the milieu has caused very striking alterations of the geographical distribution of various sorts of fish as demonstrated by AD. S. JENSEN (1939) and many others, a feature which is so obvious that the change of the milieu is perhaps more clearly emphasized through the altered distribution of fish than through the limited oceanographical data available. The whole phenomenon serves, however, to stress the great significance of the milieu to the life in the sea, and the importance of procuring sufficient hydrographical data to follow changes in the milieu.

During the past 25 years so much work has been done and so many papers relating to the hydrography of the Council's areas have been published that even a short mention of the more important ones is impossible here. On the following pages I shall there-

fore, confine mention to only a few papers, preferably those in which observations from several years are surveyed.

In 1943 A. Kiilerich surveyed the hydrography of the **West Greenland fishing banks** and gave an account of the variation of the temperature during the last fifty years as far as was possible on the basis of the rather scanty material at hand. He concluded that a relatively warm period commenced in the eighties of the last century. In the beginning of this century a cold period commenced, which from 1926 was followed by a warm period culminating in 1934. 1936 was still very warm, 1937 nearly normal and 1938 very cold. Investigations after the war have shown, however, that the cold 1938 was not the forerunner of a new cold period.

The U. S. Coast Guard has, since 1928, conducted comprehensive investigations in **Davis Strait** and the **Labrador Sea** and published the results in the *Coast Guard Bulletin*. A survey of the observations from 1928 to 1935, published by E. H. Smith, F. M. Soule and O. Mosby (1937) has greatly augmented our knowledge of the temperature, salinity and current conditions in this part of the sea, and considerable changes from year to year in the extent and speed of the East Greenland Current were demonstrated.

Anomalies of the surface temperatures of the **North Atlantic** for the period beginning 1876 have been computed and published currently by J. Smed in the *Annales Biologiques*.

The drift of the surface water of the North Atlantic was studied by F. Hermann and H. Thomsen (1946), who subjected all available drift-bottle records to a statistical treatment, and constructed a new current chart for the North Atlantic between 50° and 67° Lat. N.

The temperature variations along the **coast of Norway** have, since 1935, been recorded by means of thermographs installed in coastal liners. In this way records have been obtained which have proved to be of great value as a supplement to the observations from research ships and coastal stations. An account of the results of the thermograph records for the period April 1935—September 1938 was published by J. Eggvin (1940).

A comprehensive work on the means and extremes of the sea temperature along the Norwegian coast was published by E. Frogner (1948) who, i. a., published the monthly mean surface temperatures from a score of coastal stations, some of the series reaching back to 1867.

The seas farthest to the north have in recent years been the object of an increasing interest, both as regards fishery and hydrographical exploration. H. Mosby (1938) has dealt with the hydrography of the waters between **Svalbard** and **Franz Joseph's Land.** The observations, mainly taken in 1931, showed that the traces of Atlantic water in the northern Barents Sea were more pronounced in 1931 than in 1923 and 1929, the increase of temperature and salinity being estimated at about 1° C. and 0.04 ‰ respectively.

Further reports on hydrographical investigations in the **Barents Sea** have been given by B. Schulz and A. Wulff (1927 and 1929).

The waters bordering Western Europe have been studied under the auspices of the "Atlantic Slope Committee", which, through a series of years until the Second World War, issued the *Rapport Atlantique*. This series, to which mainly France, Great Britain, Ireland, Portugal and Spain contributed, contains extensive and valuable information on the hydrography of the waters along the coasts of Western Europe from the Straits of Gibraltar to Rockall, including studies of the variation of temperature and salinity from year to year.

All available observations of surface temperatures of the **Irish Sea** from the years 1901—1934 were examined by J. Proudman, H. M. Lewis and A. L. Dennis (1937). They calculated grand monthly means of the temperature records at Port Erin Bay together with the monthly deviations from these means and, with the aid of these, all temperature records from other points were used to calculate means for the period 1903—1931. Five charts were constructed giving the mean isotherms for the year and for the months of February, May, August and November. A report on the temperature and salinity of the surface waters of the Irish Sea, for the period 1935—1946, including a table of the annual mean temperatures at Port Erin for the period 1903—1946, was prepared by D. C. Gilles (1949).

J. R. Lumby (1935) has subjected to a careful critical and statistical treatment the temperature and salinity observations from the **English Channel** for the 25-year period 1903 to 1927 and has estimated mean values for the upper water layer for that period. The figures —calculated for 40 sub-divisions of the Channel Area— were given in a table and used for the preparation of an atlas displaying the mean isohalines and isotherms for each month.

Within the Council's field of operation the **North Sea** takes a central place, not only from a geographical point of view, but also because its fishing grounds are of great importance to fishermen of many nationalities. It is natural, therefore, that this area has attracted the attention of many hydrographers.

An excellent general account of the hydrography of the North Sea and the Baltic was given by B. Schulz (1932). Regular observations of surface temperatures and salinities have been organized from liners crossing the North Sea, and the variations of temperatures and salinities at certain selected points have been published in the *Bulletin Hydrographique*. Furthermore, regular observations from lightships along the Danish, German, Dutch and English coasts have been carried out and published, some in the *Bulletin Hydrographique* and some in national publications. The hydrographical investigations from the research ships have, however, been organized mainly to meet the needs of the individual countries rather than according to an international scheme. An attempt to organize synoptic observations by the cooperation of research

ships from Denmark, England, Netherlands, Norway, Scotland and Sweden was made in 1947, 1948 and 1949. Monthly synoptic surface charts of temperature, salinity and wind data have been worked out by J. R. Lumby and distributed by the Fisheries Laboratory, Lowestoft, since June 1950.

Several atlases of the mean temperature and salinity distribution have been worked out. In 1927 the Deutsche Seewarte published an *Atlas für Temperatur, Salzgehalt und Dichte der Nordsee und Ostsee* which, for February, May, August and November, contained iso-lines for the surface and the bottom and for the intermediate depths 10, 20, 40, 60, 80, and 100 metres. In 1933 the Service Hydrographique of the Council published an *Atlas de Température et Salinité de l'Eau de Surface de la Mer du Nord et de la Manche*, prepared by J. P. Jacobsen. This atlas, which was based on observations in the period 1902—1928 contained charts which, for each month of the year, showed the mean isotherms and isohalines. In 1934 Jacobsen supplemented the atlas with a publication in which he described the methods used in preparing the atlas, gave the mean values computed for the individual one-degree squares, and studied the variations from year to year.

Quite recently G. Böhnecke and G. Dietrich (1951) have published *Monatskarten der Oberflächentemperatur für die Nord- und Ostsee und die angrenzenden Gewässer* based on the means for the period 1906—1938.

The year to year variations of temperature and salinity have been studied by several workers. In the northern North Sea P. M. van Riel (1936) studied the variations during the period 1931—1935, and in the German Bight the anomalies of the surface temperature and salinity for the period 1923—36 were studied by E. Goedecke (1939). In 1946 C. E. Lucas and K. M. Rae published a survey of the changes of the surface salinities in the southern North Sea. They used observations collected from liners during 1930—1937 and gave a graphical representation of the salinities at weekly intervals. Maximal salinities occurred during the winter of 1934—35. Similar high salinities were reported from the periods 1920—1922 and 1903—1908. In the *Annales Biologiques* J. Smed has published monthly anomalies of the surface temperature for the period 1902—1939 and onwards.

The currents of the North Sea have been studied in various ways. J. B. Tait (1930, 1932) used the classical method of drift-bottles and, on the basis of a careful analysis of the drift of a large number of bottles liberated in the northern and middle areas of the North Sea and between Scotland and the Faroes, constructed current maps, which revealed many new features such as the existence of several eddies.

During the few years just before the war, continuous current measurements were organized from a number of lightships in the southern North Sea and the Channel and yearly reports on the residual currents were given by J. N. Carruthers in the *Rapport et Procès-Verbaux.*

In June, 1951, joint current measurements were carried out in the southern North Sea by England, Germany and the Netherlands. During a fortnight continuous current measurements were made, the data being obtained from 10 moored paddle-wheel current meters and from 5 lightships. Since the area investigated was rather small, it was possible to obtain synoptic pictures of the currents within the period.

In the **Transition Area,** where changes of salinity, and to some extent also of temperature, take place rapidly, our main sources of information are Danish, German, and Swedish lightships, the daily observations from which are published currently in national publications. Mean values of temperature, salinity and current at the Danish lightships for a long series of years were published by the Danish Meteorological Institute in 1933. Fluctuations in the hydrography of the Transition Area during a period of 50 years have been examined by Aage J. C. Jensen (1937).

The course of the mean isohalines in the Transition Area, gives the impression that the transition from the high salinities in the North Sea to the low salinities of the Baltic takes place gradually; actually, as H. Wattenberg (1941) pointed out in a noteworthy paper, the transition takes place in two steps each possessing the characteristics of a hydrographical front. The northernmost front is generally to be found near the limit between the Skagerak and the Kattegat, the southernmost and best developed front shifts between the southern Kattegat and the Dars and Drogden thresholds according to the prevailing current.

A characteristic feature of the hydrography of the Transition Area is the existence of a well marked discontinuity layer, which offers an excellent field for the study of internal waves. Such studies have been conducted especially by Swedish scientists, e. g., B. Kullenberg (1935), and were the main research object of the international Kattegat Expedition organized by the Council in August 1931.

In the **Baltic Area** most of the hydrographical information is provided by the observations undertaken mainly from Finnish and Swedish lightships, and from a number of fixed stations. G. Granqvist (1938) has worked up the Finnish observations from the period 1921—30; he has calculated mean values of temperature and salinity for the period and computed the annual cycle by means of harmonic analysis. In a later work (1949) Granqvist examined the salinities in the period 1931—1947 and found that in the thirties they were lower than in the twenties, but that they were distinctly higher in the Gulf of Finland after 1938 and also in the Gulf of Bothnia after 1943.

The variations of the hydrographical conditions in the Gotland Deep in the period 1926—1939 were studied by K. Kalle (1943), who discussed the renewal of the bottom water.

The currents in the Gulf of Bothnia and the Gulf of Finland were studied by E. Palmén (1930) by means of current measurements from 16 Finnish,

Swedish and Esthonian lightships during a period of 5 years. The mean current system in both Gulfs was found to be a weak anticyclonic movement inferior to the currents caused by the wind. The latter were closely examined together with the effect of the wind on the vertical circulation in the Gulf of Finland. The effect of a storm on the stratification of the water was further examined by E. Palmén and E. Laurila (1938).

Swedish current measurements in the Baltic led to the discovery by T. Gustafson and B. Kullenberg (1936) that a water particle described a circle of inertia during a half pendulum day under the deflecting force of the earth's rotation.

In July 1939, joint hydrographical investigations in the Baltic were carried out by Finland, Germany, Latvia, and Sweden. Observations from this international enterprise, together with earlier Swedish observations were used by N. G. Jerlov (Johnson) (1940) to set up a revised balance-sheet for the heat economy of the central part of the Baltic. He calculated that the total amount of heat annually stored and released by a column of water of 50 metres through one square metre of the surface amounted to 445,000 kg. cal.

Submarine Illumination.

In the past 30 years the methods for measuring submarine daylight have been revolutionized through the invention of the photo-electric cell.

Photo-electric cells were first used for measuring submarine daylight by Shelford and Gail (1922) who used a gas-filled potassium emission cell in Puget Sound. On the eastern side of the Atlantic similar work was taken up by Poole and Atkins, who examined various types of emission cells and used them for light measurements in the English Channel.

In 1930 a new type of photocell—the rectifier cell —was introduced by Lange. Whereas an external electromotive force is necessary for making an emission cell work, no such is needed by a rectifier cell. Its construction is very simple: on an iron plate is cast a layer of selenium of a specific modification, which is covered by a layer of gold, thin enough to transmit light. When light is falling on the selenium layer photoelectrons are liberated. The selenium layer acts as a "Sperrschicht", through which the photoelectrons can pass in the direction iron-gold, but not in the direction gold-iron. If therefore the two electrodes are connected through an outer connection, a current will flow through this, strong enough to be recorded directly by a suitable galvanometer.

In the early thirties the selenium rectifier cell was used by Utterback and Boyle (1933), H. Pettersson and Landberg (1934), Poole and Atkins (1934), and others. It was established that the main advantages of the selenium rectifier cell are its great constancy, compactness and a sensitive curve which is much nearer to that of the human eye than that of any emission cell. It was obvious that a photometer based upon the selenium rectifier cell was an instrument of such simple construction and so easy to use that it would be well fitted for routine measurements of submarine illumination in connection with biological research.

On the instigation of Hans Pettersson, the Council, in connection with its meeting in 1936, arranged a special scientific meeting on the measurement of submarine light and its relationship to biological phenomena. Leading experts such as F. S. Russell, H. H. Poole, G. L. Clarke, C. L. Utterback, A. Ångström, and H. Pettersson gave lectures on the subject and a sub-committee was formed to draw up proposals regarding methods and units of light and transparency measurements to be used in future routine measurements for biological purposes.

A report by this committee was published in the *Journal du Conseil* in 1938. Two types of standard instruments were recommended, one intended for the measurement of the submarine daylight falling on a horizontal surface and another designed for the determination of the transparency of the sea water *in situ*. The first mentioned instrument consists of a selenium rectifier cell situated immediately below a circular window in a watertight gun-metal case. Above the window can be placed colour filters and an opal glass which are easily changed. The rectifier cell is connected to a galvanometer on deck through a well insulated cable. A similar photometer placed on the deck is used to record the daylight falling on the sea surface.

The report contained detailed specifications of different parts of the instrument and precautions to be taken when used. The rate of extinction of the red, green, or blue components of the daylight falling on a horizontal surface in different depths can be calculated from the generated photocurrents provided that the relative sensitiveness of the two photometers is known, and that the "curvature error" is taken into account. The latter error is due to the fact, that the current generated by a rectifier cell is not strictly proportional to the incident radiant energy, especially under strong illumination.

If definite figures for the radiant energy available at different places in the sea are wanted, further standardization of the photometers is necessary. A sub-committee for the standardization of photocells, was formed at the Council Meeting in 1937. In 1939 the Council decided that the experimental work of the sub-committee should be taken over by the "Oceanografiska Institutet" in Göteborg under the direction of Prof. Pettersson, and in 1943 N. G. Jerlov (Johnson) and H. Olsson published a work in which they described a method of standardization, using the sun as a light source as suggested by Ångström, and a thermopile for establishing the sensitivity curve of a photometer in absolute energy units.

Using a standard photometer it is easy to measure the radiant energy falling on a horizontal surface in the sea, but this is not a direct measure for the radiant energy available, for example, to a plankton

organism, because the submarine light is not travelling in perpendicular and parallel beams. On a clear day with a calm sea the maximum light intensity near the surface will coincide with the direction of the refracted sun rays, but the longer the light penetrates into the sea, the more it will become diffuse owing to scattering by the water molecules and suspended particles. The question of the angular distribution of the submarine light and the total illumination has been studied by various authors, especially by Poole and Atkins (1929, 1936, 1940), Clarke (1936), Utterback (1936), Jerlov (Johnson) and Liljequist (1938), Whitney (1941), and Jerlov (1951).

It has been found that the ratio between upward and downward illumination ranges from 0.5 to 6 %, the highest value being found for the blue part of the spectrum in cleanest ocean water. This has a bearing on the colour of the sea, because the blue colour of the open ocean is largely due to the selective scattering of the light by the water molecules. In coastal waters the augmented presence of material in suspension accounts for a much larger proportion of absorption and scattering and, since this is nearly non-selective, the blue colour is faint; this combined with the yellow colour of the "Gelbstoff" discovered by Kalle (1938) accounts for the more greenish colour of the coastal water.

For the ratio of downward to horizontal illumination value have been reported ranging from 17 % to 90 %. With increasing depth this ratio seems to approach 60 %.

It has become general practice to report the vertical extinction coefficient $\varkappa$ as a measure of the extinction of daylight in the sea. This coefficient is defined by the equation

$$I_1 = I_0 \cdot e^{-\varkappa}$$

where I_0 is the light intensity falling on a horizontal surface at a certain depth, and I_1 that falling on a horizontal surface 1 meter further down. The ratio $\frac{I_1}{I_0}$ is called the vertical transmission and is also often reported. It must be remembered that both these quantities are dependent not only on the properties of the sea water but also on the altitude of the sun, especially for measurements near the surface.

The selenium rectifier cell (in a simple modification) is also sensitive to ultra-violet radiation and has been used by Jerlov (1951) on the Swedish "Albatross" Expedition for measuring the penetration of ultra-violet radiation into the sea. He found a very marked difference between the transmission in clear ocean water and that in coastal water, the transmission at 310 mμ being as high as 86 % per m. depth for the ocean water and at most only 10 % in coastal water. The great difference is attributed to the presence of "Gelbstoff" in the coastal water.

The question of the dependence on milieu-factors of the life in the sea has recently been the subject of discussions at the Council meetings. These confirmed the supposition of the founders of the Council, that exploration of the milieu is a necessary link in scientific fishery investigations. The problem:— on which milieu-factors should the main emphasis be laid in future, and at what places and times should field investigations of the milieu be carried out, can be adequately solved only by close co-operation between biologists and hydrographers.

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2.

Plankton.

By R. S. Wimpenny

Descriptive Work.

The very large number of species with its wide representation of the majority of the classes of animals in the zooplankton, the variety of forms in the phytoplankton and the extent of their habitat, absorbed most earlier effort in the descriptive field of taxonomy, the elucidation of life-cycles and exploratory surveys. This vast task was by no means finished at the beginning of the period under review and the volume of work referring to it is so great that it can only be dealt with here in the most cursory fashion, picking out a few points which have appeared specially important.

Notable taxonomic studies have been furnished in respect of the zooplankton by Rose (114) (copepods), Lebour (79) (decapods and molluscs), Gurney (48) (decapod larvae) and numerous groups in appropriate parts of "Die Tierwelt der Nord- und Ostsee" (43) and the "Fiches d'Identification du Zooplancton" edited by Russell and Jespersen (123). Phytoplankton groups have been treated in a similar way by Hustedt (64) and Lebour (80) (diatoms), Schiller (130, 131) (dinoflagellates and coccolithophorids) and Gemeinhardt (36) (silicoflagellates). To Braarud (11) we are indebted for the recognition of genotypical form variation from form to form.

For mistakes and confusion in determination mention must be made of the work of Lebour (81) for pandalids, Meek (94) for the species of *Sagitta*, Rees (112, 113) for the species of *Calanus* and lamellibranch larvae, and the writer (144) for species and varieties of *Rhizosolenia styliformis*.

Probably the most interesting feature of the taxonomic field, however, has been the definition and identification of naked flagellate species of small size, often called "μ flagellates", which we owe to Parke (107) and Butcher (14). The present indications are that a small species, *Chromulina pusilla*, is the commonest organism of this type to be found in the sea.

A great deal of light has been shed on the breeding generations of copepods by Nicholls (96), Marshall, Nicholls and Orr (90), Russell (117), Bogorov (4), Ruud (125), Marshall (87), Wiborg (141), and Digby (21). Most small species showed five broods a year in temperate seas and fewer further north. Similar work has been done on *Evadne nordmanni* by Jorgensen (74), and *Sagitta setosa* and *elegans* by Wimpenny (145), Russell (119), Ussing (139), and Pierce (108).

Among diatoms Gross (44, 45) has shown that apart from a regeneration of size by auxospore formation in *Ditylum Brightwelli*, resting spores removed from the parent cell would regenerate cells at the large auxospore size again. Normal germination of these spores was within the parent cell wall when cells of the same diameter would be formed. A one-, and a three-to four-year auxospore cycle has been reported in two parts of the North Sea for *Rhizosolenia styliformis* (144). Microspores have been widely observed in diatoms and Braarud (9) succeeded in showing their development into vegetative cells in *Chaetoceras decipiens*.

An indication of the distribution of some of the most important work done in the different parts of the Council's area will appear from the following analysis of references (see p. 29).

Some of the results drawn from these surveys will be discussed later, but before closing this section mention should be made of the rather important general findings in the Baltic. Here it appears that the heaviest crops were in the eastern part, but the larger numbers of species in the west. Since the middle thirties there has been a considerable northward spread of salinity in this sea and corresponding changes in the plankton have taken place. An instance of this is *Aurelia aurita* which has spread rapidly eastwards along the south coast of Finland and now breeds in areas formerly unsuitable to it.

Semi-tropical Atlantic and Mediterranean	Jespersen (68), Faure (24), Bernard (2, 3).
North Atlantic Ocean	Hentschel (60), Steemann Nielsen (99), Jespersen (68), Rae (110), Corlett (19).
European coastal waters	
British and southern North Sea	Russell (118, 121), Corbin (16, 17, 18), Harvey, Cooper, Lebour & Russell (58), Harvey (56), Savage (126), Savage & Hardy (127), Savage & Wimpenny (128), Wimpenny (145), Künne (78), Wulff (150), Hardy, Lucas, Henderson, Rae, Marshall, Fraser, Stubbings & Rees (54), Gibbons & Fraser (37), Fraser (28, 29), Marshall & Orr (88, 89), Marshall, Nicholls & Orr (90).
Danish	Jespersen (73), Steemann Nielsen (100, 104), Thorson (138).
Norwegian	Føyn (26), Gran (40, 41, 42), Braarud (10), Ruud (125), Sømme (134), Wiborg (141).
Baltic	Hessle & Vallin (63), Mielck & Künne (95), Hentschel (62), Levander (82), Segerstråle (132), Steemann Nielsen (103).
Greenland and Iceland	Jespersen (69, 70, 71), Braarud (8), Böhnecke, Føyn, Hentschel & Wattenberg (6, 7).
Barents Sea	Wulff (151), Manteufel (86).

Organic Production.

From the descriptive and exploratory activities which I have shortly summarised, some important explanations, ideas and theories on organic production, physiology and ecology have emerged.

In considering the first of these we have to turn to the fundamental physiology of the phytoplankton on whose ability to synthesize carbohydrates from CO_2 and water and to assimilate soluble inorganic salts from the medium so as to synthesize living protoplasm, the rest of the organic life in the sea depends.

Gran (40), utilising the measured release of oxygen in bottles containing local plankton and suspended in the sea off the Norwegian coast near Bergen, estimated that the production per square metre down to the depth at which photometabolism took place was much greater in one month than Atkins gave as a minimal annual estimate for the English Channel using pH changes. In the Barents Sea Kreps and Verjbinskaya (75) following another method of Atkins by which the difference between the summer or spring minimum and winter maximum of inorganic phosphorus was made the basis of a minimum estimate of organic matter produced, showed that a higher value was obtained in the Barents Sea compared with the English Channel. The Sound between Denmark and Sweden has been carefully investigated using Gran's method (100). Steemann Nielsen found that its production was rather poor, giving an annual estimate the equivalent of 110 g. of glucose per square metre of sea surface which was equal to only two-thirds of that for one summer month in the NW. Kattegat.

Apart from the method of estimating organic production by the production of oxygen or by pH or phosphate differences, the seasonal differences in nitrates, and silicates have also been employed by Cooper (15), who has summarised estimates of minimal annual production for the English Channel expressed as wet weight of phytoplankton in metric tons per square kilometre in the following manner.

CO_2 (pH)	1,600
O_2	1,000
Phosphate	1,200
Nitrate	1,500
Silicate	110

Only the silicate estimate appears to be seriously out of step and this is thought likely to be the result of repeated use and breakdown during the annual cycle.

Studying the phosphate distribution, Bernard (3) has shown that in the Mediterranean near Algiers, the region of highest potential fertility is well below the surface between 50 and 250 metres. This is in the neighbourhood of a layer of water lying between the surface Atlantic current and the underlying deep waters of the Mediterranean.

The estimates of plankton just mentioned are based on the assumption that the differences of the nutrient material measured represents a given proportion of the plankton by weight. Schreiber, (129), however, using chiefly the unicellular green algae *Carteria*, was able to show that when using phosphates or nitrates in small quantities the amounts of one or other of these substances could be equated to the number of diatom cells present and one could, in fact, tell from a count of the cells the amount of the nutrient that had been used in their production.

The most recent method of measuring organic production has been devised by Steemann Nielsen (105). It consists in finding the amount of radioactive carbon-14 contained in sodium bicarbonate

which is taken up by filterable particles in sea water in a given time and under given conditions. Bottles with sea water to which the active bicarbonate has been added are either exposed in the sea from sunrise to sunset or are placed on a rotating plate in a water thermostat and subjected to an illumination of about 16,000 lux for a given period. In either case the samples are then passed through a collodion filter of 0.5 μ pore aperture and the impulses from the filter counted using a Geiger-Müller tube.

Production estimates to date suggest that it may be greater in higher latitudes, but the evidence available is still scanty and the question may still be regarded as an open one. However, this may be, it is clear that heavier "standing crops" of plankton are to be obtained towards the northern part of the Council's area. Friedrich (30) has illustrated this point as far as the Atlantic is concerned by obtaining equivalents for the many types of gear used to sample plankton in the different investigations. The chart he has produced shows a steady increase to the north and north-east of the Atlantic sea area with which we are concerned.

The annual estimates of plankton production based on phosphate changes are minimal and in this connection it has to be remembered that Harvey, Cooper, Lebour and Russell (58) showed that diatoms passed through grazing copepods in an undigested state, and Gardiner (35) has demonstrated that inorganic phosphate may be rapidly produced by plankton animals.

Probably the most important single result from the work of the many surveys of the last twenty-five years has been the confirmation of Nathansohn's views on the important contribution made by nutrient salts from the deeper layers and the minor effects of land run-off. Together with this there has arisen a new understanding of the importance of vertical mixing and the degree of such mixing capable of producing an optimum crop. An interesting example of this is cited by Braarud and Klem (13) who studied the hydrography of a section seawards from the coast at Møre for which the phytoplankton had been investigated by Gran (42). Here Gran had found an earlier flowering of phytoplankton to take place in the coastal fjord and at stations off the coastal bank (Storeggen) than in the intermediate coastal waters and he had at first been inclined to attribute the outburst in the coastal fjord to land run-off. Braarud and Klem point out, however, that the different phasing of the flowering is attributable to differences in stabilisation of the water masses and resulting movements of diatoms and nutrient rich water into the photic zone. The earlier development of phytoplankton in the fjord as compared with the coastal sea was thought to be due to the more vigorous vertical movement of the sea in the latter area. A deep and vigorous vertical circulation in the early part of the year in this district means that the plant cells only spend a short time available for growth in the shallow zone in which they can carry out photosynthesis. Their maximum development is therefore retarded as compared with that closer inshore and further offshore where these conditions are not so manifest. Other similar cases to this have been reported, particularly notable ones being referred to by Steemann Nielsen (99) in his study of the waters in the neighbourhood of Iceland and Greenland.

Outside the mixing or water stability factor, light, amount of nutrient, oxygen, CO_2, sinking rate, predators and the presence of the necessary number of vegetative cells or spores are all liable to limit and condition the optimum production of phytoplankton. Finally, there must be added to these the complexity of the community of species involved, as it has been pointed out by the writer (145) that simple communities with few species may be associated with superior standing crops of plankton.

An attempt at a dynamic appraisal of the upgrowth of phytoplankton and the part of this used by predators has been made by Fleming (25) and there is no doubt that this piece of work on population dynamics now familiar to those who deal with fish populations will be the forerunner of many fruitful investigations on the plankton.

Before leaving the general problem of production mention should be made of the success of certain experiments in enclosed or semi-enclosed sea areas where phosphates and nitrates have been added. Beneficial effects were observed in Norway, by Gaarder and Spärck (31), and in a Scottish Sea Loch by Gross, Raymont, Marshall and Orr (46). The plankton, however, did not always respond favourably to the addition of nutrients (92) and it is likely that some other factors were involved, and that the problem of directing the nutrient salts to the right address will repay some further study.

Physiology.

Knowledge of the physiology of plankton organisms is a field in which the advance, although considerable, has been somewhat diffuse and scattered.

Support for a generalization on individual size has emerged from studies on the life histories of various zooplankton species. It appears that the overwintering generation in *Calanus finmarchicus*, *Pseudocalanus elongatus*, *Paracalanus parvus*, *Acartia clausi*, *Temora longicornis*, *Centropages typicus*, *C. hamatus*, and *Oithona similis* (4, 21, 87) together with *Sagitta elegans* (119, 145) and the medusa *Phialidium hemisphericum* (120) produce larger individuals than the generations that follow. Moreover, in copepods generally the size of individuals of the same stage is greater in the colder water of the Arctic than in temperate regions (Jespersen (67)). In the North Sea I have found *Sagitta setosa* of the same stages of maturity larger in the deeper part of the area and in the case of both *S. setosa* and *S. elegans* the generation that passed through the winter grew to the largest size. These findings are in line with observations on the

increase in size of land mammals and birds in cooler areas generally known as "Bergman's rule".

Another question connected with the physiology of assimilation is the contention of Pütter that aquatic metazoa absorb substantial amounts of dissolved organic matter from the water around them. This thesis was carefully examined by Krogh (76) as a contribution to the Council's Special Scientific Meeting, on General Physiology. He concluded that the process suggested by Pütter could be of little consequence in the metazoa and that in fact it rarely took place.

The oxygen consumption of *Calanus finmarchicus* has been worked out by Marshall, Nicholls and Orr (91) and by Raymont and Gauld (124) who found the rate for the stage V copepodite at 17° C. to be 0.5 μ C per copepod per second. The latter investigators also studied other species of copepod in this respect.

The rate of uptake of food has received some attention. Lucas (84) using *Eurytemora hirundoides* showed that the rate of feeding averaged 5,000 cells per hour per copepod and was roughly proportional to the concentration of the *Nitzschia* supplied. *Calanus finmarchicus* has, however, been the subject of most of the experiments and here Harvey (57) found 74 to 94 ml. of food-bearing water per *Calanus* to be swept clear in 24 hours. Gauld (39) using stage V *Calanus* came to the conclusion that about 70 ml. per 24 hours were swept clear of *Chlamydomonas*. The range was from 42 to 101 ml. or from 250,000 to 2,000,000 *Chlamydomonas* cells. Other investigations on the subject have been made by Lowndes (83) and Raymont and Gross (111). Analyses of protein and fat for the various stages of *Calanus* have been made by Marshall, Nicholls and Orr (90) and the fat has been shown to be stored when food is plentiful.

In the early part of the period the effect of light on the vertical distribution of zooplankton in the sea was ably and exhaustively reviewed by F. S. Russell (116), and towards the end a similar service was done to the subject by Cushing (20). In the meanwhile there had been numerous special investigations among which may be mentioned those of Russell (115), Spooner (135), Sømme (134), Störmer (136), Nicholls (97), Marshall and Orr (88), Jespersen (72), Hardy and Paton (53), Gardiner (34), Foxon (27), Farran (23), Fage (22) and Bogorov (5). Russell's results in the various responses shown by the different stages of *Calanus* and the fact that the generations of this species in July were at a higher level in the water near Plymouth may be taken as a typical result. Most observers are agreed that aggregation at an optimum light intensity is the most likely explanation of diurnal vertical migrations in plankton animals.

Diurnal vertical migration in the marine phytoplankton has recently been demonstrated for the first time by Rytter Hasle (59). Species of *Ceratium* were shown to withdraw from the surface in the daytime, whilst *Goniaulax* and *Prorocentrum* moved towards it.

Schreiber (129) in his classic work of 1927 has shown the effects of temperature and light on the growth of certain diatoms. *Biddulphia sinensis*, for instance, grew best in warm water at 10° C., whereas *B. mobiliensis* made more divisions in cooler water, but in respect of light had an optimum below the green alga *Carteria*.

An optimum light intensity for oxygen production in *Coscinodiscus exentricus* has been shown by Jenkins (65). Gabrielsen and Steemann Nielsen (32) exposed *Nitzschia closterium* to light of different wave lengths and found that blue light was more effective for photosynthesis than red. Recent work by Wassink and others (140) suggests that light energy absorbed by accessory pigments may be effectively transferred to chlorophyll for further use in photosynthesis.

The effect of various salinities on the growth-rates of different types of mobile phytoplankton has been clearly indicated by Braarud (12). Braarud showed that for each of these types there was an optimum salinity and that above and below this value the rate of growth fell away.

For many years the problem of how diatom populations were maintained in the upper illuminated layers of the sea in view of the belief that the cells of which they were composed would tend to sink has been a baffling one. Gross and Zeuthen (47), however, have recently demonstrated that the specific gravity of diatoms may be lower than that of sea water and that the cell-sap maintains a much lower proportion of divalent ions than sea water, as the result of a continuous exertion of energy.

While the general physiology of phytoplankton organisms is such that their optimum growth needs the satisfaction of the chemical and physical factors that have been described, and the differences in these factors may account for the differences in temporal and geographical distribution, some species can adversely affect other organisms by the release of a specific effluent. An example of this sort has been afforded by the peridinean *Prymnesum parvum* which Otterstrøm and Steemann Nielsen (106) report as having killed fish in a Danish broad, and the effect generally has been discussed by Lucas[1]).

Ecology.

The ecological aspect of plankton studies has been marked by the importance given to the concept of plankton indicators and theories on the relation of plankton plants and animals and of the relation of plankton to plankton-grazing fish.

Contemporary work on the first problem stems largely from the observations of F. S. Russell (121) who, following up the suggestions of Meek (94) in respect of the relative abundance of *Sagitta elegans* and *S. setosa* and their connection with hydrographic

[1]) Lucas, C. E. (1947): The ecological effects of external metabolites. Biol. Rev., **22**. 270–295.

conditions showed that these two species might be taken as signs or indicators of water masses of high and low fertility respectively and of different origins. In an able review of the literature on this subject F. S. Russell (122) has listed a number of species which may be taken as markers or biological indicators of water masses of a certain physical type and origin. These indicator organisms have been found not only to be a guide to the water in which they live but also often to be representatives of special background communities of animals and plants, which are not so readily to be identified. Striking confirmation of earlier views on the relative fertility of *S. elegans* and *S. setosa* water has emerged lately from the work of Wilson (143) who found that certain benthic larvae which would not develop in *setosa* water did so readily in *elegans* water.

The general inter-relationship between the zoo- and phytoplankton has given rise to considerable discussion and not a little observation centring around the hypothesis put forward by Hardy (Hardy and Gunther (51) and Hardy (49)) that dense patches of phytoplankton exclude animals. An important part in the animal exclusion postulated by Hardy is played by the vertical migration of the herbivorous zooplankton which moves towards the surface containing phytoplankton during the night, remaining there for a time inversely proportional to the density of the phytoplankton. As the currents of the upper and lower layers of water are often different a horizontal exclusion is brought about due to the zooplankton being carried away from the phytoplankton rich upper layers by the movement of the water in the lower layer. Steemann Nielsen (101) while agreeing that Hardy's hypothesis may at times be an explanation of the situation, thought that the inverse relation between zooplankton and phytoplankton so commonly found in the sea is mainly due to the slower development of the former, making its maximum appear so much later.

Harvey (56) has formed conclusions of another sort. As a result of his work in the English Channel, he considers that the phytoplankton is often regulated in its abundance by the intensity of grazing of the zooplankton. This would often account for an inverse relationship between zoo- and phytoplankton.

Savage and Wimpenny (128) and Wimpenny (145) observed that diatom patches in the North Sea were the resort of young and breeding zooplankton, and they have suggested that the high oxygen production to be expected in such areas might have a favourable effect on brood survival and so help to turn these patches into favourable nursery grounds. Some recent work by Marshall and Orr (93) on egg production in *Calanus* has shown this to be largely dependent on the phytoplankton food available. The circumstance of food alone may therefore cause the diatom patch to appear as a nursery area.

As an example of the relation of plankton to fish a few results from the considerable amount of work done on the herring may be cited. At times, but not always, there is a correspondence between the catches of herring and the local density of the plankton—often mainly *Calanus*—upon which these fish feed (Hardy, Lucas and Henderson (52)). The relation between these two factors appears to be a balance which is more complicated than was at first imagined and is at present still being worked out. On the other hand, certain plankton organisms and dense phytoplankton patches have been thought of as always negatively related to the herring and to be avoided by their shoals (Savage and Hardy (127), Savage and Wimpenny (128) Lucas and Henderson (85)). These views may yet have to be modified, however, as a recent unpublished observation by Dr. D. H. Cushing showed echo traces of fish shoals in a moderately dense patch of the diatom *Rhizosolenia styliformis* and suggested that this species may not be avoided by fish to the extent previously believed. Moreover, it has to be noted in this connection that Savage and Wimpenny (128) observed a massing of herring shoals and zooplankton on the edge of diatom patches.

Fundamentally, of course, all our food fishes depend directly upon the plankton at some stage of their lives and in the case of the cod in the Baltic, Poulsen (109) has pointed to a correspondence between successful year-classes and the abundance of plankton. Detailed links in the chain of cause and effect have not yet been worked out, however, although it is known from the investigations of Wiborg (142) and Soleim (133) that a scarcity of plankton may result in the death of post-larval fish.

The condition of the plankton as indicated by the fat-content may also affect the condition of the herring that feed upon it, causing the fat-content of muscle in the latter to reach its seasonal maximum in July a month later than the former (146). A relation between the fat-content of Baltic plankton and the growth of the local herring has also been noted by Jensen (66).

Among phytoplankton organisms quite high fat-contents are occasionally reached; up to 40% of the dry weight of *Coscinodiscus concinnus* has been recorded, probably from morbid populations (148). This species has been found responsible for the production of great areas of oil-covered sea, so thick that sea birds have been entangled and fouled in it, although no harm has been reported to fish (137).

Sampling and Methods.

While for macroplankton the stramin Petersen young-fish-trawl and 2-metre ring-net, for mesoplankton the Hensen egg-net and international tow-nets of No. 3 silk, for microplankton the international vertical net with No. 25 silk, and for nannoplankton samples the Nansen-Petterson water bottle, continue to have been used; several modifications and new ideas have arisen with regard to methods of collection and sampling.

One of the most important of these has undoubtedly been the use of flow-meters in the mouths

of silk nets first introduced by HARVEY (55) for fine silk vertical nets, and now employed in tow-nets, and the Hensen egg- and larva-nets. A device which has been used at sea more extensively than in earlier periods is the plankton pump in the form used by GIBBONS and FRASER (38). These workers found pump samples very satisfactory for small meso-plankton and for microplankton, the organisms being collected in silk nets placed over the delivery end of the pump. For most purposes, however, the metered nets have turned out to be much simpler and more practical, and larger quantities of water can be more quickly dealt with.

The method of centrifuging water samples for microplankton has tended to be less used during the last twenty-five years. STEEMANN NIELSEN (98, 102) in introducing the sedimenting of marine micro-plankton samples and their estimation by a reversed microscope, considered that this method was superior to the use of the centrifuge, and that it proved the unreliability of the silk net for this type of plankton. HENTSCHEL (61), on the other hand, although he thought the centrifuge an efficient device when used with care, abandoned its use in favour of a method of filtering known volumes of water through very fine-meshed metal sieves.

A new and radical departure in plankton collection is represented by the Hardy Continuous Plankton Recorder (50). This high-speed collector towed behind ships gives a continuous record of the plankton on a strip of silk. Successful surveys carried out by its use have already emphasized its importance for indicator organisms, and there is little doubt that much more is to be expected of it in the future.

Apart from trials of the comparative efficiency of different types of net made by KÜNNE (77), tests on the sampling errors involved in the collection of plankton have been made by GARDINER (33), who found that in a series of consecutive hauls made with coarse international vertical nets there was a 25% error in 75% of the samples. WINSOR and WALFORD (149) tested the catches made by other workers mainly with Hensen nets. Assuming that the plankton was randomly distributed they used a Poisson distribution and found an error for vertical nets of about 25 %. This was thought to represent differences in the volumes of water filtered. BARNES and MARSHALL (1), however, eliminated differences of volume and still found substantial error using a Poisson distribution for statistical tests. They thereafter assumed that the error was due to the fact that plankton organisms were not randomly distributed, but occurred in patches. Assuming two types of "contagious" distribution which would cover patchiness, their tests resulted in fair agreement for the small zoopnklaton organisms with which they worked.

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Abbreviations used:
J.M.B.A. = Journ. Mar. Biol. Assoc. U.K., Plymouth.
For the Council's own publications:
R.P.-V. = Rapports et Procès-Verbaux. A.B. = Annales Biologiques. J. = Journal du Conseil.
NB.—All titles have been abbreviated.

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3.

The Cycle of Nutrient Salts and Marine Production.

By KURT BUCH

THE chemical nutrient basis for living organisms in the sea certainly ranks among the most important subjects of chemical oceanography. A notable advance in this field of research at the turn of the century was K. BRANDT'S wellknown theory that marine productivity is, according to LIEBIG'S "minimum-law", regulated and limited by certain mineral nutrient salts, probably phosphates and nitrogen compounds, which had not been detected in sea water at that time. The marine chemists' problem now was to find methods of proving the existence and making quantitative determinations of these salts. In this respect outstanding research work was done at the Plymouth Laboratory. In 1923 was published the first applicable method for determining phosphate and silicate, soon followed by a method for determining nitrate. The methods were then applied to investigating seasonal variations of nutrient salts and their relation to periodicity of plankton production. The research had now entered an extremely active phase. In 1928 investigators from various institutions for marine research were called to a Special Hydrographic Scientific Meeting to discuss their experiences in this field[1]).

The following paper first reviews the further development of the research methods and then deals with the function of nutrient salts.

I. The Methods.

After the Special Meeting in 1928, mentioned above, a conference was convened in Oslo by Professor JOHAN HJORT and attended by representatives from Norway and other countries with the assistance of several Norwegian colleagues. The conference worked during October at the "Biologisk Laboratorium" of the University and had for its main task to intercompare different methods proposed and draw up working directions on the basis of experience gained. In addition, general research results were discussed and plans for further research made. Travelling expenses were provided by the International Council.

A memorandum was published[1]) which: "may be of assistance to others engaged in research upon life in the sea". It may be said that the results were promising, the methods applicable but still by no means satisfactory.

Later development brought considerable technical improvement. All methods now used are optical and have developed side by side with the progress of general colorimetric and spectrophotometric instrumental techniques. The ideal instrument is certainly a modern spectrophotometer, which can be easily handled for work on board. These have now been constructed and are being adapted for use at the laboratories of oceanographic institutions and on board expedition ships.

Early investigations mainly concerned phosphates and nitrogen compounds occurring in the sea water as decomposition products of organic matter. The principal nitrogen compounds are ammonia, nitrite, and nitrate, the first mentioned appearing in the water immediately on the beginning of decomposition then followed by nitrite which finally is oxidized to nitrate. As the general problem of the nutrient salts cycle was being attacked, attention was also focussed on other nutrients belonging to the minor constituents of the sea and on more abundant nutrients, not themselves limiting to growth of living organisms but of which the relation to limiting factors must be known to enable estimation of the extent of production. Of the minor constituents iron especially may be mentioned, but in what form it is present in the water and how it is utilized have been, and still are in some respects unsolved problems. However, there are now some very sensitive methods at least for determining iron ions. Also other elements with a biological function can be determined, e. g., silica, iodine, vanadium, manganese, zinc, copper, etc.

[1]) The lectures delivered at this meeting were published in Rapp. et Proc.-Verb., **53**, 1929 (see p. 44, Bibliography, A_1).

[1]) Rapp. et Proc.-Verb., **53**, p. 95, 1929.

For a range of heavy metals the so-called dithizon-method which was developed and adapted especially for analysis of sea water is recommended.

In connection with the development of working methods mention may be made of some activities initiated by the Council. There arose a question of more formal character but still of no less importance, namely nomenclature. From various quarters the desire for expressing published data similarly and in the same units had been expressed. The question had been discussed at the Council meetings in 1933 and 1935, and in 1934 a special committee was appointed by the Council. The committee collaborated with different investigators from several oceanographical institutions in U.S.A., England, Canada, and Germany. In 1936 the committee delivered a preliminary report, and in 1938 a final report to the Council. Another question was how to standardize the working methods. The matter was brought up for discussion at the Council Meeting in 1935, and again a committee was appointed which could when necessary rely on assistance. At the Council Meeting the following year a report was given summarizing the results of exchange of opinions and presenting the unanimous opinion that it is impossible to draw up standard directions in such close form as had previously been given for determination of salinity, e. g., chlorine-content. The fact was stressed that it is in the nature of chemical reactions that a universally applicable working rule cannot always be followed. The committee was then commissioned to give a detailed critical report on the most reliable methods in use at the time, and to point out uncertain factors severally so as to make it possible for every investigator to have a survey of the different methods and their efficiency. The report, written by H. Wattenberg, was presented in 1937.

The Carbon Dioxide System.

The amount of major constituents of the sea water is, as we know, practically proportional to the salinity of the ocean and of these constituents those which are biologically utilized act as constant factors. There are, however, also some widely varying factors among which is oxygen, analysis of which presents no problem, and, equally important, carbon dioxide or rather the whole carbon dioxide system, including dissolved carbon dioxide gas and carbonic acid to carbonate, bicarbonate, and hydrogen ions. Recognition of the influence of this system on various processes of geological, oceanographic-physical, biological, and even climatic character, and, consequently, of its importance to research on these processes combined to give weight and novelty to investigations of the system. It was studied along with the nutrient salts question. At the Council Meeting in 1930 the equilibria between the above-mentioned states of carbon dioxide, as controlled by the law of mass action, were surveyed and preliminary data respecting the most important equilibrium constants, which vary with temperature and salinity, were presented. At the same time a working programme was established aiming at a method for determining all constituents in a water sample of known salinity and temperature by only one single analytic determination, and that was pH. In some cases a second determination, that of titrating alkalinity or total carbon dioxide content, is necessary. At the meeting in 1930 the Council appointed a working committee, which in the spring of 1931 met in Helsingfors, Finland, at the Institute for Marine Researches. For this work the Council granted means to procure the necessary instrumental equipment. The Council received a report of the results in 1932, and later another report concerning the influence exerted upon the equilibrium by the boron content in the sea water, which in the meantime had been detected and found to form so high a percentage as to necessitate its inclusion in the system.

In 1938 a new determination of the second apparent constant of carbon dioxide, as obtained by means of more complete and precise instruments, was presented as well as two of its thermodynamic constants determined elsewhere with a precision not as yet attained. These new facts necessitated a review of the whole system in 1951, in which however the conclusions of the two previous reports were verified in all the essentials. Only a few trifling deviations in numerical values were found, and these were at

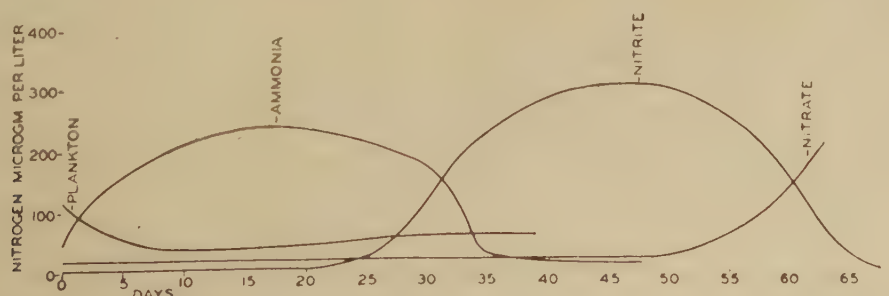

Figure 1. The decomposition of nitrogenous organic matter in mixed plankton showing the appearance of soluble nitrogen compounds in the water. Laboratory experiments by v. Brand, Rakestraw and Renn.

the lowest temperatures and lowest salinity (brackish water), and at high pH-values, >8·5, which are infrequent.

Application of the system for elucidating the relation of nutrients to production is illustrated below. Success is vitally dependent on the precision with which a pH-determination can be made. In connection with the critical review of the methods for determining nutrient salts, given by H. Wattenberg (1937, B I), the colorimetric pH-determination method was surveyed. Nowadays the electrometric method with glass electrodes can also be used with identical results. An equipment is being designed specifically for sea water purposes, namely for sampling and measuring within a quite closed system.

II. Nutrient Salts and Phytoplankton.

Introduction of the new methods led to extensive investigations especially of phosphates and nitrogen compounds at nearly all oceanographic institutions and on a great many sea expeditions. The most important result of the efforts was undoubtedly the confirmation of the theory on the function of these salts as limiting factors. Already at the first Council Meeting where these questions were discussed, viz. in 1928, convincing evidence in support of the theory was presented by E. Schreiber (1927, B I), who reported an entirely biological method for determining phosphate and nitrate in sea water. The method was based on determinations of rate of production in cultures of certain algal species, as estimated by the number of cells which a known amount of phosphates and nitrogen generates in the water. It was proved in the North Sea that under different seasonal conditions both phosphate and nitrate appear as limiting factors at different times. Later work provided ample confirmation by chemical methods.

A general result of the first phosphate and nitrogen determinations was the detection of the sources of the nutrient salts supplies. Previously it was generally assumed that the main supplies derived from land drainage. These supplies certainly are of importance but have proved to be practically completely consumed close to the shore and to cause a separate shore production. However, production in certain open sea areas, which is often extremely rich for instance near the large fishing-banks, in contrast to the veritable water deserts often of immense area, but with the most minimal production, was explained by the discovery of the *circulation of nutrient matters* in the sea, which nowadays is well known. By this phrase is meant the concentration in the depths of the sea of material rich in phosphorus and nitrogen formed by the rain of decomposed organisms, after their death in the surface layers; transportation of nutrient salts to the surface by upward currents due to earth-rotation, trade-winds etc. in certain geographically favoured areas; and, so, in consequence production of new generations of life, first phytoplankton, thought of as the primordial substance of the sea and forming in turn a nutrient substratum for a long sequence of populations of animal organisms: zooplankton, small fish, big fish, up to the very giants of the sea, the whales, nearly all of which frequent the same upwelling areas where the mineral substances have been pressed up to the surface.

An especially important contribution to the knowledge of this circulation in the Atlantic was made by the German "Meteor" Expedition in 1925—27, which drew up the principal lines for both the horizontal and the vertical water circulation in this area, and elucidated the upwelling of enormous amounts of phosphate and nitrate in the South Atlantic and along the west coast of Africa with concomitant enormous riches of living matter of all types occurring in the sea. From the southern waters on the Atlantic boundaries the "Discovery II" contributed to the study of nutrients, which made this remote and stormy area one of the best known in this respect.

The first investigations of nutrient salts were principally directed to inventorying the stocks of nutrient salts in the sea in relation to thereon dependent phytoplankton production. A fairly sure

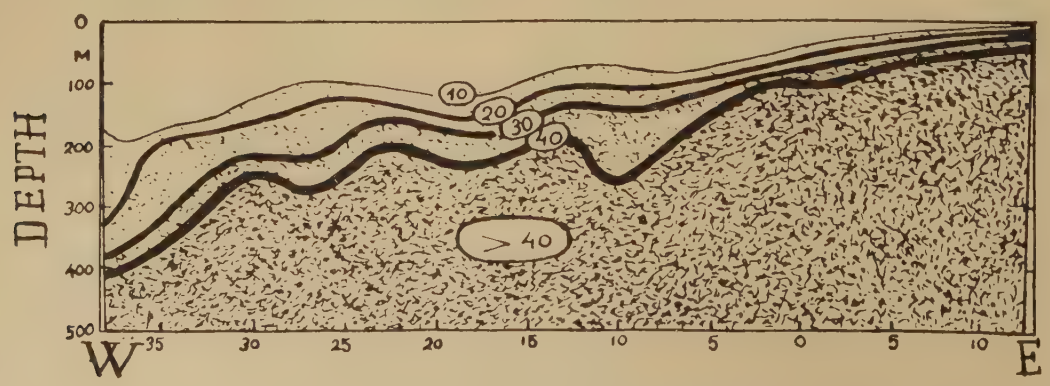

Figure 2. Distribution of phosphate (PO_4—P mg./m.³) in a section South America–Africa 9° S.

conception of its rate in most of the sea areas has been obtained, as well in surface waters as in the depths, and not only by single determinations, but in several places also by regular sampling during the year and for years in succession. The laboratory at Plymouth has again led the way for the investigations in this field with its profound studies in the English Channel. Experiences of great importance have also been achieved in the Gulf of Maine, and similar observations have been made at the Arctic shores, in the Baltic, etc.

As stated above, the study of these circumstances is also connected with all the investigations of a physical character, which have brought knowledge of those different forces maintaining or inhibiting the transport of salts, the effect of which is rather varying in different areas. A closer treatment of these functions is not, however, necessary in this review.

All above-mentioned investigations and general experiences may be said to belong to the first phase of nutrient research. Its results are definite, they are published in manuals and text books, and are partially studied already by school children.

Further research in this field is characterized principally by the aim to achieve quantitative ratios of the nutrients to the amounts of living matter generated by them, or more concisely expressed: to enable determination of the total by the amount of the nutrient salts entering into production within a defined area and during a fixed time, for instance one year. The extension towards depth is fixed in a natural way as it coincides with that of the photosynthetic zone.

The task turned out to be a very complicated one. Production is dependent on many different and varying factors, the majority of which may change from year to year. Calculations with mathematical certainty are thus not to be counted upon. And yet, does not the nutritive value of the soil also give the farmer a chance to estimate his coming harvest?

The first question concerns production of the organic primordial substance, the phytoplankton. Different procedures have been applied. The first was the use by Atkins, 1922, of the change in pH. The procedure most used consists in regular determinations at different depths of the nutrient content, considering mainly the easiest determinable phosphate, and beginning the investigations in winter when the photosynthetic activity is poorest because of minimum light, the water from the autumnal mixing is fairly homogeneous and the amounts of nutrients raised from the depth are to some extent accumulated, and in combination herewith to take plankton samples establishing the crop of plankton per volume unit, or as is most customary, below a unit area of the sea. During the progress of spring a more or less sudden outburst of phytoplankton, mainly diatoms, sets in consuming practically the whole stock of nutrients and also the fresh supplies produced during the vegetation period. This vegetation season is of a similar character in the whole temperate zone. In the English Channel it usually can start as early as in January, further north in February—March, and even later. The exact point of time varies also in the same place from year to year. The vegetation soon reaches a maximum but decreases again with the appearance of zooplankton, which graze on it until soon hardly anything remains. The duration of the period seems also to vary with the latitudes, being shorter and possibly more intense on higher latitudes. Its shorter duration is likely to be connected with the stronger stratification in higher latitudes owing to the fast spring warming of the surface, which more effectively inhibits the upward transport of new nutrients from depth. Its greater intensity is due to the greater number of day light hours. At lowest latitudes, where practically no seasonal temperature variations occur, the upward transport and consumption of nutrients is more continuous. The progress can now be observed by regular sampling establishing how much phosphate on the average disappears daily from the water and how much living matter is produced. The procedure is very schematic and involves uncertainties, which however cannot here be dealt with. A condition is to be able to express satisfactorily the rate of generated phytoplankton. Formerly the cells were counted under the microscope, which is possibly sufficient for solely biological purposes, but not satisfactory assuming a general view of production, mainly because the cell volumes of the different species are so extremely different from one another. Certainly the only correct way would be to express the production in weight, either the weight of the most important separate elements contained in the plankton crop, or the weight of its most important organic compounds: protein, carbohydrate, lipoids. Investigations on different lines carried out by several investigators have opened the way for determining weights of this kind.

Experiments made by Gessner (1943, B III) indicate that the chlorophyll content of phytoplankton cells provides a direct measure of the capability of the plants to produce organic matter. The chlorophyll content is colorimetrically determined, preferably with a sensitive spectrophotometer. The chlorophyll is extracted; the depth of the yellow-green colour in the extract is directly proportional to the chlorophyll concentration. The colour can then be expressed in arbitrary limits proportional to the concentration of a permanent standard (consisting of a mixture of nickel sulphate and potassium chromate) of the same colour.

When further knowing the ratio of chlorophyll to organic matter the first mentioned can also be used as a measure of the whole plankton crop. The ratio naturally varies somewhat for different species and may even vary within one and the same species. Nevertheless, it has been found that representative samples of phyto-plankton taken from whole water columns and consisting of many species give average values of the ratio mentioned, sufficient as rough values of the magnitude. A few data from an

excellent summary by H. W. HARVEY (1950, B III), may illustrate this matter: Analyses of catches made on several occasions from bottom to surface in the sea off Plymouth and containing primarily diatoms, showed that diatoms containing one unit (one U.P.P.[1])) of the permanent standard mentioned contained 0.00013 and 0.00010 mg. of phosphorus.

Owing to the remarkable conformity in composition shown by chemical analyses of phytoplankton HARVEY was able to proceed to an estimate of the content of dry ash-free organic matter in an amount of diatoms containing one U.P.P. This was stated to be 0.016 mg. for a mixed community from all depths in the English Channel. The author mentions that the value should be regarded as a rough approximation. The obtaining of more exact determinations, however, meets with very great difficulties.

Upon application of these experimental results to sampling of phosphorus and plankton catches made in accordance with the already presented working scheme during February and June in 1948, and in 1949 too, in the English Channel, HARVEY finds, starting from a total decrease of the supply of phosphorus of 0.409 below a square metre during these 5 months, the ash-free vegetable tissue amounting to 53—65 g. However, for the whole year of 1949 he estimates the total production "unlikely to have fallen short of 120—200 g. organic matter below a square metre (an average of 0.4—0.55 g. daily), and may have been considerably more". It is inferred that the decrease in phosphate is less than expected because the original stock of phosphorus after having been consumed by the first generation is excreted and reappears in mineralized form in the water, being then consumed again.

Now it would be desirable to determine the rate of multiplication or, on the whole, to find a way for determining the total amount of plant substance that has grown during a vegetation period. For this purpose, however, mere determinations of phosphorus are insufficient as the basis of production. Other nutrients must also be examined for this purpose, partly in parallel with phosphorus: e. g., consumption of nitrogen compounds, principally nitrate, consumption of carbon dioxide (pH), and production of oxygen by photosynthesis. Nitrate determinations have not, as a rule, been approved of, as the analysis seems to cause difficulties. Carbon dioxide has the advantage that the photosynthetic activity of plankton is estimated by a determination of the pH-increase in the water; unfortunately it also indicates the opposite respiration process by a corresponding pH-decrease. There is, however, some experience in this respect gained by respiration experiments with phytoplankton. The value of a loss of 4 % daily of the organic matter has been used. Another disadvantage using carbon dioxide is its exchange with the atmosphere though this is of concern only in the surface layer.

The determination of oxygen in water also has advantages and disadvantages. As an example of procedure we refer to RILEY's (1941, B III) investigations in the Gulf of Maine. Water samples were placed in both transparent and dark bottles, which were kept some days at sea temperature, whereupon the oxygen was determined. The difference between the light and dark bottles indicated gross production by the plants. The loss by respiration, however, which does not show in the analysis, must be separately determined by calculation from the estimated plant life. Perhaps three more bottles could be filled in a similar way and the pH determined, immediately, and after keeping for some time in the light, and in the dark? Carbon synthetized from the depth of the photosynthetic zone below a square metre was determined from the oxygen month by month.

HARVEY (1950, B III) has converted the carbon figure into organic matter on the basis of analyses of diatoms, proving that 1 g. of carbon is equivalent to 2.24 g. organic matter. The amount of organic matter produced during a whole year rose to 270 g. or an average of 0.8 g. daily, to be mentioned as a very rough estimate. It is to be noted that this production value includes the organic matter produced by nutrients which have been used many times over.

The above estimates of the production were possible because the photosynthesis decisively dominated over the respiration, which again could be estimated separately. pH-determinations alone seem so far not to have led to reliable results. It may be noted that they must be executed with utmost care. Also oxygen determinations can give only rough assessment of production. Combined determinations controlling each other, such as those performed for example at the Plymouth Laboratory, may give safer results. The procedures used in different cases and the valuation of different methods depend to a great extent on the nature of the vegetation progress. Two extreme types may here be compared: In the Baltic, for instance, the diatom outburst happens almost explosively consuming the whole stock of phosphorus within a few weeks, reaching a maximum at a steep curve and disappearing again nearly as rapidly. The consumption of phosphorus and the growth of the plant crop has taken place before the zooplankton even gets time to join the game. Growth and decomposition occur at entirely different phases, and for this first phase at least we may count with an approximate proportionality of consumed nutrient salt to grown organic matter and calculate this in the above-mentioned manner from the amount of disappeared phosphorus for instance using the quotient C : P : N. In this the figures for decrease of carbon dioxide (increase of pH) and the increase of oxygen, with a due adjustment for the respiration, give effective support.

[1]) $= 4.6 \times 10^{-6}$ g. $NiSO_4 6H_2O$ and 25×10^{-6} g. K_2CrO_4.

The other type of production progress occurring on lower latitudes is the more or less continuous production throughout the year already mentioned. There, the nutrients on their way to the surface may be consumed in the lower part of the photosynthetic zone, with the animal organisms grazing the phytoplankton as this germinates. A stationary state arises between photosynthesis and respiration, including decay. The nutrient content is very low, the proportion of plant to animal density is more or less constant, and so is the pH and oxygen content. The analytic values tell us nothing of the intensity of metabolism. In areas of the kind described one is restricted to experimental observations of living material.

In most cases the production investigator probably has to deal with a form intermediate between these two types and may work on the broadest front using the most versatile methodology possible.

The surest way to a reliable knowledge of the production seems to be the one taken by most oceanographic institutions since the beginning of production research in the 1920's: a chosen area is made the object of long-term observations recording throughout the year physical as well as chemical and biological factors, and connecting chemical analyses of the living matter and experimental observations with cultures of mixed communities or dominant forms. Some recent results of these investigations may be referred to, as well as new suggestions of causes of fluctuations. They add further emphasis to the necessity of collecting statistical material from long-term observations. In addition, new micro-constituents, such as manganese, and other inorganic elements, as well as various organic compounds have been found, of which a very minute addition increases the division rate of many species of plankton algae. Some of these organic agents derive obviously from land drainage. A valuable discovery was that certain plankton species lived in a water mass of a distinct type and special derivation but were missing in water of another type, characterized by some other species. These indicators of the water mass have enabled observation of the change of water movement in areas where the usual indicators, chlorinity and temperature, appear to have little significance.

The last two decades have seen many production estimates from different sea areas. The short survey, Table 1 below, gives comparable results from some of the latest calculations, with a few older calculations, which except for RILEY's observations have not been contained in previous comparative summaries.

III. Animal Matter.

The principles for the determination of the rate of production of phytoplankton from the nutrients, should be applicable to the corresponding investigations into the production of successive stages in the whole cycle of organic production. The aim then would be to determine the yearly production yield of every item with an unchanging perpetually circulating capital of raw material, broadly speaking. We have advanced as far as gaining a certain estimation of the rate of generation of the first living product, phytoplankton, in certain production areas, but not much farther. Efficiency of exploitation declines with every new type of population living on the preceding one. Fish and other animals at high levels of the food chain secure only a minute part of the whole nutrient capital.

Thus HARVEY (1950, B III) states in an experimental calculation of the percentages of different types of animal matter generated from 100 g. of assimilated vegetable tissue that the first succeeding

Table 1.

	Organic matter, grams below a square metre	
	During the time stated	Daily average
The English Channel, ATKINS 1928, and COOPER 1933, Jan.–June (6 months)	85–190	0.5–1.1
The sea of Plymouth, HARVEY *et cons.* 1949 whole year (minim. quantity)[1]	120–200	0.4–0.55
The Gulf of Maine, RILEY 1941, whole year (nutrients used several times)	270	0.8
The Sound of Elsinore Denmark, STEEMANN NIELSEN 1937, whole year	110[2]	0.3
The Isefjord Denmark, STEEMANN NIELSEN 1951, whole year	600[2][3]	1.6
Hangö (the Baltic), BUCH and GRIPENBERG 1935, min. quant.[1] 21st March–21st April[4]	24	1.2
STEEMANN NIELSEN, Average production from a corn-field	600	

[1]) The phosphorus thought of as used once only.
[2]) Calculated as carbohydrate.
[3]) "Real photosynthesis" ("apparent photosynthesis + respiration — the respiration af bacteria and small zooplanktons enter in the calculation").
[4]) Rapid diatom outburst from beginning to its maximum.

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generation, herbivorous short-lived zooplankton, makes use of all of 70 g., whereas of pelagic fish for instance feeding on herbivorous zooplankton is formed only 4-7 g., to which can be added only a

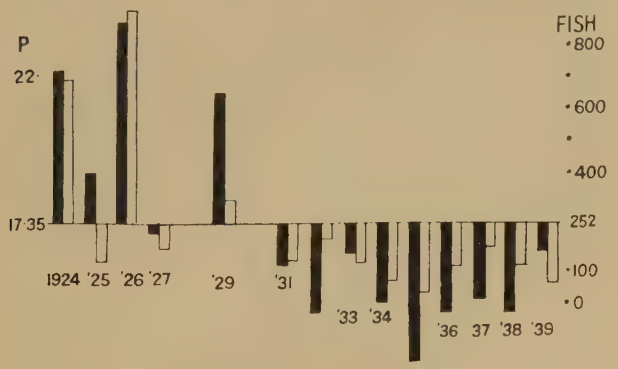

Figure 3. The horizontal line represents the mean maximum phosphate content of the English Channel near Plymouth. The black pillars show the phosphate content (mg. phosphorus per ton) in the water at the beginning of the year and the outlined pillars the average number of young fish caught during the following summer.

few percent. for the weight of animals living at the bottom, such as worms and demersal fish, feeding on bivalves.

Nevertheless the original nutrient content does seem to play a part in determining the production of later stages. The results from quantitative net hauls made at weekly intervals over fifteen years by Russell (1935, 1937—40, B III) show close relation between the phosphate in the water at the beginning of each year and the number of young fish spawned and surviving during the summer (Fig. 3). They also show the great difference between the years. In the English Channel, during the 1920's the winter-maximum of phosphate was much greater than during the 1930's. The change-over took place towards the end of 1930, followed by corresponding decrease of the number of the summer spawning young fish and to an even greater extent of the number of almost all planktonic organisms.

IV. Fertilization of the Water with Nutrient Salts.

Recognition of the importance of nutrient salts to the production inspired the idea of artifical fertilization of sea water. Fertilizing an open sea area was surely out of the question, although even that was suggested, but it might be done in a comparatively closed gulf or firth in combination with planted fish. On a small scale there should be repeated the course of events happening at the open sea: the salts would generate plant matter which is grazed by zooplankton benefiting in turn the fish. The fertilization proposition was realized in a grand experiment supported by Scotch industries and was followed with great excitement by marine biologists all over the world. The experiments were carried out in 1942—47 in the Loch Craiglin, and in a smaller firth near by, on the west coast of Scotland, where flounder and plaice were planted and at fixed times nutrient salts spread out. However, the experiment turned out in an unexpected way; not that the fertilization would have been ineffective, on the contrary. The Loch Craiglin was within short transformed into one of the richest natural feeding grounds known. But the nutriment benefited principally the bottom vegetation which showed an immense development. In other words: a weed-field was created instead of a culture field. By and by it was also noted that the body-weight of marked fish was, when caught, considerably higher than that of other fish of the same age. Economic profit was not derived. The experiment raised a lively discussion and stimulated profound investigations into the nature of conditions for plantation, what they were and what they should have been. Here, details must be omitted. It appeared that the firth chosen was unsuitable for the purpose in many respects. We quote Cooper: "if certain salient features could be dealt with such an enclosed loch might be made far richer in fish production than anything other in Nature".

V. Exchange of Matter between Sea and Sea Bottom.

The foregoing survey has indicated that life in the sea is maintained by its own relatively constant capital of perpetually circulating nutrients. Mention was also made of the supply from land, which is considerable but never reaches the large open expanses. For completeness also the exchange of matter between sea and sea bottom and so also between sea and atmosphere should be dealt with. Data respecting the former are still rather limited. A part of the decomposed organic matter not completely mineralized and dissolved could be expected to form sedimentate and thus fall out of the circulation cycle. The little known about phosphorus seems to show that no appreciable amounts of this are concentrated on the sea bottom. Nitrogen is found in greater amounts in bottom sediments but the yearly loss can be considered insignificant and in any case be covered with supply from the atmosphere. On the other hand the effects respecting calcium carbonate are more extensive. The upper layers of the sea are permanently supersaturated with calcium carbonate. Supersaturation is greater at lower latitudes but also occurs at the northernmost latitudes. This circumstance is, without doubt, a favourable factor in the generation of limeshell organisms, as the precipitation, whether biological or chemical, is not energy-requiring but energy-producing. In shallow water there is a continuous sedimentation of lime derived mainly from land. In deeper waters, however, a dissolving of lime occurs, due to

more acid pH-level, and there lime is dissolved also from the bottom sediment. This means that we are observing a present geological transformation of the sea bottom on a large scale. Except for the lime precipitating organisms these processes have probably slight influence on the production of living matter.

In this connection the enormous yearly sedimentation of silicate scale should also be observed. Redissolving of silicate like that of calcium carbonate is insignificant. The exchange is practically one-sided. The loss is richly covered by the supply from land drainage.

Exchange between the Sea and Air.

As to the exchange of matter between sea and atmosphere, mention may first be made of the fact that the atmosphere contains considerable quantities of nitrogen in the form of ammonia, nitric acid and nitrous acid, which are delivered to the sea by falling of rain. The total amount of all this nitrogen in various forms may, according to roughly estimated calculations based on analyses of rain water and snow, give rise to about 10 mg. daily of organic matter per square metre, corresponding to an appreciable percentage of the total production. Evaporation of ammonia into the atmosphere does not take place because the ammonial partial pressure of the atmosphere is far greater than that of the water.

More remarkable than the nitrogen exchange is the carbon dioxide exchange. Anyone following the outburst of diatoms in spring may note that while carbon dioxide assimilation increases pH to 8.3 or 8.4 rarely over 8.5 or 8.6, the oxygen content increases correspondingly. At this pH the concentration of carbon dioxide and bicarbonate ions is reduced to such an extent that continued production would be inhibited were it not for the moving balance with unlimited amounts of carbonate ions, which produces new material for assimilation as old material is consumed. For this reason the supply of carbon dioxide is also considered unlimited. However, these balance reactions are partly time reactions and, especially at low temperatures, remarkably slow. With good reason we may therefore ask whether or not the velocity of metabolism is reduced after all.

A general observation during the phytoplankton outburst is that the highest pH-values do not occur in the surface layer but somewhat below it, at a depth of about 10 m., which is an evidence of the losses to be covered by inflow from the atmosphere. The partial pressure of carbon dioxide of sea water in the surface is on the average 2.9×10^{-4} atm. decreasing during the vegetation periods by a half or more. Phytoplankton then competes successfully with land vegetation for carbon dioxide supplies of the atmosphere.

The inflow of carbon dioxide from the atmosphere into the sea is not, however, restricted to periods and areas of vegetation only, but takes place during the main part of the year in probably the greatest part of ocean surface, which fact has been proved by comparative determinations of carbon dioxide pressures of the atmosphere being on the average $3.2–3.3 \times 10^{-4}$ atm. and of sea water all over the North Atlantic, North Sea, and the English Channel as also in areas of minimal biological activity. As a consequence one should expect an adjustment of balance in the course of thousands of years, and it is evident that there has been some adjustment, as the above difference in pressure between sea water and atmosphere is small ranging from 0.2 to 0.3×10^{-4} atm. This difference in pressure with consequent transfer of carbon dioxide from the atmosphere to the sea, demands an explanation: During the last decades, i. e. from about the turn of the century, the carbon dioxide content of the atmosphere has increased considerably, by at least 10 %, in consequence of the immense increase of industrial combustion during this time. This is evident from all the atmospheric carbon dioxide analyses made by different investigators independently of each other and by different methods. Besides, research has proved that the total amount of this surplus delivered to the atmosphere during this time as estimated from analytic results conforms well with the total amount calculated on the basis of industrial statistics on the

Figure 4. Schematic diagram of the carbon dioxide circulation above and within the North Atlantic partly based on Bjerknes' scheme for the air circulation above the Atlantic.

combustion of fossil fuel during the same time. This conclusion finds further support in the fact that the carbon dioxide pressure of sea water in areas where for some reason or other no sub- or superpressures

occur, is on the average the same as was the average partial pressure of carbon dioxide in the atmosphere at the turn of the century, i. e. about 2.9×10^{-4} atm. In the arctic and probably also antarctic waters the carbon dioxide pressure owing to the low temperature decreases down to 1.5×10^{-4} atm. Higher pressures and transport from the water into the atmosphere take place only in upwelling areas as on the west coast of Africa and others. Figure 4 shows a schematic diagram of the carbon dioxide circulation above and within the North Atlantic made with the aid of BJERKNES' scheme for the air circulation above the Atlantic.

Accordingly, sea and atmosphere were in closer balance at the turn of the century than today. Naturally this difference will be equalized, the sea will even take over the greater part, i. e., about $^7/_8$ of the new surplus, but this process proceeds slowly. In the meantime, enormous amounts of carbon dioxide stream into the sea for the benefit of its living world, a manifestation of the fact that in the production of living matter the consumption of nutrients, in which also man plays his part, whether it occurs at first within the hydrosphere, atmosphere or lithosphere, has an indirect influence on the whole global biosphere.

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4.

The Transplantation of Fish.

By Å. Vedel Tåning

From time immemorial man has been proud of his transplantation of fish from one water to another; an example of such pride is the runic stone from Gausdal in Norway which records: "Ailifr algr bar fiska i Raudsio" (A. carried fish, viz. trout, up into Rausjø, in East Gausdal.) Much other evidence is available from nearly all parts of our globe, of fresh water fishes being transplanted from east to west, from north to south, for man's benefit and pleasure.

The first transplantations of marine fishes in north-west Europe and America were carried out only comparatively recently and this has induced the erroneous idea that transplantation of marine fishes is a new departure. However, in the Far East, transplantations of young marine fishes have been made since time immemorial. It suffices here to mention as an example that the raising of milk-fish (Chanos) is of very ancient origin in Hawaii, the Philippines and in several other localities, where fry have been and still are caught every year in the coastal areas and fish raised from them in ponds of salt, brackish and fresh water.

In European countries the interest in transplantation of species of marine fish to waters in which they do not occur naturally increased during the later part of the nineteenth century and the beginning of this century, probably due partly to the success of transplantation and artificial propagation of fresh water fishes and partly to the declining fisheries in some coastal and off-shore waters. Much experimental work was done with disappointing results, but some successful transplantations were accomplished (e. g., the shad, *Clupea* (*Alosa*) *sapidissima* and the striped bass, *Roccus lineatus*, etc.). The increased knowledge of the physical-chemical environmental factors of importance to the development of the fry and of migrations and feeding habits of young and adults etc., which has been obtained *inter alia* through the international research work, has improved the prospects for transplantation experiments at the present time, when, moreover, the development of aeroplanes and helicopters as well as freezing techniques makes transportation much more simple than during the pioneering days. Although this line of research has been of some importance to the fresh water fisheries in many countries, it has not been of any important profit to the salt water fisheries during this century. One of the reasons for this is probably the discouraging experiences in some fresh water fish transplantations, e. g., of the Pacific salmons; millions of eggs of these species have been transferred to numerous localities all over the world, but only in a very few localities (South Isl. of New Zealand, Chile and a few others) have natural stocks been established.

Another reason is very obvious especially where north European waters are concerned: introduction of new fish species into these waters does not offer rich promise for the future because our seas are already crowded with a valuable variety of delicate species so that appreciable benefit could therefore hardly be obtained. In these waters the problems are those of maintenance of the various valuable fish stocks and, if possible, of augmentation in number and growth. Accordingly we are, in our waters, not interested in the transplantation of species, but rather of great quantities of specimens, fry or young fish from overcrowded nursery grounds with too little food to sparsely or unoccupied areas rich in food.

During the half century, when the International Council has advanced the knowledge of the sea and its inhabitants, some valuable progress has been made in transplantation of fish fry or young fish. The ideas on this form for transplantation were put forward during the first years of international co-operation but have so far proved to be not adaptable for international accomplishment.

Johs. Schmidt emphasized in one of his first papers on the life history of the eel (1906, Rapp. et Proc.-Verb., Vol. V) that the most important practical result of his investigations was likely to be that elvers would be transplanted in great quantities from the Atlantic coasts to such parts of north and central Europe that elvers or young eels, through natural water ways, could reach either not at all or only in small numbers. This result aroused much interest, partly because it

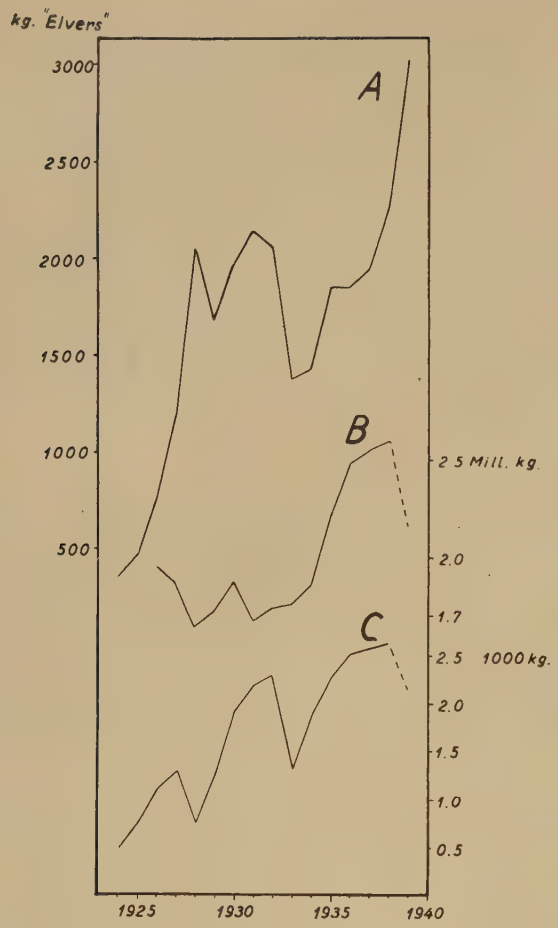

Figure 1. Transplantation of Elvers to German Waters.
A. Weight of transplanted fish.
B. Total yield of the fishery.
C. Yield in lake of Bodensee.

was promoted by the International Council. Schmidt pointed out that elvers were fished in thousands of kgs. (there are about 1900—7000 elvers to a kg.) in England, France and Spain to be used for human consumption and even as food for swine or manure. He emphasized how the fisheries in lakes and other inland waters would benefit if some part of these great quantities of elvers were transplanted. The matter aroused interest especially in Germany. Some experimental transplantations from Normandy and the river Arno in Italy were carried out, but it was the successful transplantations carried out by "Deutscher Fischerei-Verein" from Epney near Gloucester at the mouth of Severn which brought such fine results from 1908 up till the World War I; one year up to 7 million elvers were transplanted. The transplantations were continued after the war when the late fisheries director in Hamburg, H. Lübbert, was the enthusiastic promoter of this large-scale enterprise. Even as late as in 1939 about 10.5 million elvers were transplanted. Certain lakes in central Europe have shown great increases in yield of the eel-fisheries after transplantation over a long series of years (Fig. 1). The practical results of these transplantations have often been emphasized and are actually among the greater practical results achieved from investigations under the sponsorship of the International Council. There can be no doubt that these transplantations will be continued; two world wars have put great obstacles in the way of these continuous transplantations from west to central Europe, but the results seem of such practical value that they must continue.

Transplantation of elvers is also carried out in several other European countries, e. g. France, Holland, Sweden, and Denmark. In Denmark the number of elvers transplanted has varied between 0.2 to 6.1 million annually in the years 1922 to 1950. Moreover, as in several other countries, in Denmark young eels are also transplanted in great quantities—up to 10,500 kg. annually.

The transplantation of elvers is comparable with the mentioned transplantation of Chanos in the Far East.

We will now turn to the advancement in transplantation of exclusively marine fishes.

In Europe transplantation of **marine fishes** on a commercial scale from an overcrowded nursery area to an area rich in food but poor in fish dates back to 1892 when this procedure was carried out with young **plaice** in the **Limfjord** (Jutland). The procedure became known internationally through the work on this line by the delegate to the International Council Dr. C. G. Joh. Petersen, especially after the large-scale transplantations begun in 1908 when for the first time more than one million young plaice were transplanted to replenish impoverished grounds. Except a few years during the two great wars this transplantation in the Limfjord has been continued every year with 0.75—2.5 million young plaice. The value of the yield to the fishermen has been estimated generally to be 100—200,000 Danish Kr. annually; this is to be set against an expenditure of 20—30,000 D. Kr. (one year as much as 45,000) defrayed by the Government.

Owing to great annual variations in yield from the transplantations some experimental alterations of the procedure have been carried out now and then to try to obtain a maximum yield to the fishermen. Final details as to procedure and amount of young plaice transplanted are near to being obtained but have yet not quite been fully settled.

When the stock of plaice became heavily overfished in the **Belt Sea** during the twenties Dr. A. C. Johansen, Director of the Danish Biological Station, proposed transplantation to this area of young plaice from *inter alia* the nursery ground in the North Sea off south Jutland. These experimental transplantations to the inner Danish waters began in the spring of 1928. The young plaice were obtained partly from the Horns Reef area and partly from the Nissum

Figure 2. Chart of the Limfjord. The Plaice are caught for Transplantation into the shaded areas, in the western part of the Fjord. The large figures in the inner Broads indicate the number of Plaice transplanted to the various areas in April, 1932. The figures in brackets denote the corresponding quantities in Kg. (From H. Blegvad, 1933).

broad (western Limfjord) and the adjacent coastal area of the North Sea. From the last-mentioned areas the plaice were transported in well-boats to the localities of liberation in the Belt Sea, but from the Horns Reef area they were carried by fish lorries or by train across Jutland from Esbjerg to Fredericia and from there they were distributed by well-boats to the different localities of liberation. In the year 1928 1.4 million young plaice were liberated at an expense of about 45,000 Danish Kr.; the size of the plaice was about 17—27 cm. A. C. Johansen published a short paper on this experiment in the *Journal du Conseil*, III, 1928, pp. 367—370. By this, a new epoch was inaugurated in the Danish plaice transplantation experiments and they were received with enthusiasm by the Danish fishermen and have been continued since. The numbers transplanted have in some years risen to 2.1 million young plaice. It was not given A. C. Johansen, who died 1931, to publish more on these experiments, but his successor, Dr. H. Blegvad, continued the work and published in 1932—34 some much quoted papers on the first years' very successful experiments. The papers called forth much interest on such transplantations of young fish from overcrowded areas to good feeding grounds, and similar experiments were eventually carried out in various countries, e. g. Germany, Norway, and Sweden. I will quote Blegvad as to the course of procedure used and the results obtained, especially during the first period of these transplantations to the inner Danish waters.

"The first large-scale transplantation was started in 1928: one and a half million plaice (weight 103,000 kg.), taken partly from the westernmost broad in the Limfjord and partly from Horns Reef in the North Sea off Esbjerg, were transplanted to the Belt Sea. The procedure was mainly the same as in the Limfjord: through the Board of Fisheries an agreement was made with a fish-merchant, who had the necessary means of transport, to supply the stipulated weight of plaice of 17 to 25 cm. in length from the North Sea at a fixed price and under certain conditions. The most important conditions were as follows:

1. After being landed at Esbjerg the plaice were to be kept in well-boxes for at least 48 hours before being carried overland to Fredericia (a harbour on the east coast of Jutland) in a closed fish-lorry. This was necessary in order to rid the plaice of the stomach content, consisting of crushed shells of bivalves, which in transit overland might hurt the intestines of the fish.

2. At Fredericia the plaice had to be kept in well-boxes for at least another 48 hours to allow the fish to accustom themselves to the fresher water of the Belt Sea.

3. From there they were carried to the place of liberation by well-smacks of at least 20 tons gross. The maximum load was fixed at 2,000—2,500 kg. as estimated by the Fisheries Inspectorate.

4. The contract price was paid at the place of liberation, but only for fish which, in the judgement of the government inspectors, were likely to live.

Figure 3. Diagram of the Transplantation Experiments from the North Sea to the Belt Sea during the years 1929—1933. The plaice were caught in the Horns Reef area at Esbjerg, where they were kept in well-boxes for 2—3 days before the transport by fish lorries to Fredericia. Here the fish again were kept in well-boxes for some few days. The transport to the places of liberation took place by means of well-smacks. — In the figure each fish denotes 10,000 plaice and the ways of transport are shown by heavy black lines. (From H. Blegvad, 1933).

5. Liberation of the fish was to begin during the first half of April and to be concluded before the end of the same month.

As in the Limfjord, the actual work of liberation was supervised by the Fisheries Inspectorate, and the markings and the working up of the results by the Danish Biological Station. Two to three thousand fish were marked every year during the first years but later on only about 1,000 fish per year were marked.

As the first transplantation proved to be extremely successful, the transplantations were continued during the following years, the annual number of fish transplanted in the period from 1928 to 1939 inclusive being between one and two million plaice. The Second World War, however, put an end to this activity, which was not resumed until 1946.

While in 1928 the plaice were taken partly from the Limfjord and partly from the Horns Reef, in the period 1929 to 1939 they were taken solely from the Horns Reef. In this area there is a constant overpopulation of plaice with a slow growth-rate. Since 1946 all plaice have had to be taken from the Limfjord, but the long transport on well-boats (sometimes 24 hours or more) has apparently not resulted in a mortality of any importance (hardly 2 per cent.). Consequently these transplantations will be continued.

It has been demonstrated by the investigations carried out by the Danish Biological Station that the transplantations to the Belt Sea, like the Limfjord transplantations, have been successful. Marking experiments have brought to light the following facts.

1. The percentage of recaptures of the transplanted North Sea fish shows that at least one third of all the plaice transplanted are recaptured by fishermen. The recapture of marked plaice ranged between 21 and 39.5 per cent. from 1928 to 1933, decreasing subsequently to figures between 7 and 12.5 per cent. because no rewards were paid after 1934 for marked plaice below the minimum size, and also because the former fee of 2 Kr. per label forwarded was reduced to 1 Kr.[1]). Accordingly most of the labels were not forwarded, and a calculation based on these figures cannot be made. From the monthly recaptures of marked fish before 1934 the value of the North Sea fish recaptured by the fishermen can be calculated month by month. From these calculations it appears that the total value of the fish—marked and unmarked—recaptured amounts to 100,000—200,000 Kr., while the actual cost of the transplantations may be put at about 40,000 Kr. The Government's annual grants are about 50,000 Kr., but part of this sum (about 10,000—12,000 Kr.) goes to the scientific control, marking work, rewards for the marked fish sent in by the fishermen etc.

2. The marked plaice remain near the localities where they have been liberated.

3. The growth of the transplanted plaice is very rapid, 10—12 cm. during the first growth-period, which is more than the growth of the local Belt Sea fish. At the same time they have gained fivefold in weight.

It is a well-known fact that the North Sea plaice are racially distinct from the plaice of the Belt Sea. The shape, too, is different, the North Sea fish being more slender, so that the fishermen are usually able to sort out the transplanted fish in their catch. On this basis, they all admit having benefited from the transplantations.

The transplanted North Sea fish are older than the Belt Sea fish of corresponding size, the former being already three to five years old at transplantation, while the Belt Sea fish of the same size are only two years old. Also the otoliths are different, the growth-rings being uniform and rather broad in the Belt Sea plaice, whereas the rings in the North Sea fish show an inner series of very narrow zones, corresponding to the number of years spent in the Horns Reef area, and another series of broad zones, testifying to the rapid growth in the Belt Sea. Accordingly race and age analyses have enabled us to ascertain the percentage of North Sea fish in the catches of the fishermen. From these observations we have calculated the income of the fishermen from the transplantations to be a sum varying from 100,000 to 200,000 Kr. annually.

Thus, by calculating in two different ways we have come to the same result, that these transplantations have been very profitable. In order to bring about increased results from the transplantations, a closed season for female plaice in the transplantation areas was introduced in 1933, the closed season being the months of February and March, the spawning period of the plaice. In fact, it has become apparent that

[1]) Later on again raised to 2 Kr. and even 5 Kr. without much better results. (Author's remark).

many of the transplanted plaice spawn in the Belt Sea, and while the male plaice are good marketable commodities, the spawning females are meagre and watery, so that they should be spared."

During the last 25 years transplantation of young plaice has moreover begun in a third area, viz., the **North Sea,** where the difficulties in transplantation have proved to be much greater than in the Limfjord and the Belt Sea area.

Few days before his death in 1880 FRANK BUCKLAND wrote on fishery problems and referred to the North Sea as a potential "great fish farm" awaiting more knowledge before it, like fresh waters, could be brought under conditions of cultivation. This was emphasized by the late Professor W. GARSTANG of the University of Leeds when, as Buckland professor for 1929, he lectured in Grimsby and Hull and stressed his proposal of 1905 in which he put forward for the first time, at one of the first meetings of the Council, the idea—based on the Danish plaice transplantation experiments in the Limfjord—that transplantation of plaice to the rich Dogger Bank area ought to be carried out. He concluded his lecture with an appeal to the great British fishing ports Grimsby, Hull, Shields and Lowestoft, that they should "take the first step towards cultivating the 'Great Fish Farm' which lies at their very doors."

At the 23rd meeting of the International Council in Copenhagen, in spring 1930, a proposal on transplantation of plaice from the Danish inshore waters to the Dogger Bank was again presented (by Dr. A. C. JOHANSEN) and was considered in the Consultative Committee; a sub-committee was appointed to consider the commercial prospects of such a transplantation experiment (Rapp. et Proc.-Verb., Vol. 66, pp. 26 and 30). Dr. A. C. JOHANSEN gave an account of the Danish operations in transplanting small plaice from the North Sea to the Belt Sea and adjacent waters, and produced evidence that these operations were a success commercially. The sub-committee agreed that a detailed enquiry into the costs and probable success of a large-scale transplantation should be undertaken and that a meeting should be held in London (later altered to Lowestoft) at the end of October with the attendance of a representative of the British fishing industry. In the meantime the members should study the question and relevant information should be interchanged. This was recommended by the Consultative Committee and adopted by the Council; Dr. E. S. RUSSELL was asked to convene the meeting.

The meeting on the commercial prospects of transplantation of plaice to the Dogger Bank was held on 3. November 1930 in Lowestoft. Professor W. GARSTANG, who was the first to propose transplantations to the Dogger Bank, was present. Dr. A. C. JOHANSEN was, however, unable to be present owing to ill-health from which he never recovered; his scheme for transplantation of plaice to the Dogger Bank should however not be accomplished for many years.

The full report of the Lowestoft meeting was printed in Rapp. et Proc.-Verb., Vol. 74, 1931, pp. 105—115. The results of the work of the Committee were condensed in the following statement (l. c., p. 109): "The Committee having considered the estimates contained in the appendices annexed hereto, is of opinion (A) that the probable cost of transplanting one million plaice from the Horns Reef area to the Dogger Bank would be £ 3,000, including the cost of control, (B) that the probable yield from these plaice in two years would be from £ 7,400 to 10,000, (C) that the yield from the plaice if left on the Danish grounds may be estimated at £1,000, (D) that the favourable effect on growth rate on the Danish grounds cannot be estimated.

It draws the conclusion that the probable profit of the operation would be from £ 3,400 to £ 6,000, after allowance has been made for all contingencies. It accordingly recommends that this large scale transplantation experiment should be undertaken as soon as possible."

Some members proposed that the transplantation should be carried out in April 1931, some other countries were, however, reluctant, and actually nothing happened.

The overfishing of the North Sea went on during the thirties, nearly to the bitter end. The centre of the North Sea plaice fishery shifted from west to east: in 1920—21 English fishing vessels caught about 85 % of the plaice in the central North Sea, but after the war Danish cutters caught about 80 % of the plaice there. The Danish seine fishery therefore became more and more dependent on the maintenance of the North Sea plaice stock. During the years 1932, 1933, 1934, and 1938, a series of experimental transplantations of marked plaice were carried out by the Danish fishery research vessel to study the conditions on the Dogger Bank, and the value of a large-scale experiment was stressed several times (TÅNING, 1934 and 1935). In the late forties the declining fishery after the rich immediately post-war fishery emphasized once more the need for action. The Danish fishermen's organisations, which were accustomed to transplantation of plaice in the Limfjord and the inner Danish waters, then proposed in 1948 that a large-scale experiment should be carried out from the Danish side alone. At the instigation of the Danish Minister for Fisheries, CHR. CHRISTIANSEN, the expenses were obtained from the Danish Government for transplanting 1 million young plaice in each of the two years 1949 and 1950. The ideas of BUCKLAND, GARSTANG and JOHANSEN were thus eventually realised.

After the mentioned preliminary experiments in the thirties when samples of marked live plaice were transported by the research vessel "Dana" from the Esbjerg area to the eastern part of Dogger Bank, experiments on a commercial scale were finally carried out during 1949 and 1950. Various methods of transport were tried: 1) live-fish exporters with many years experience in transport of live plaice in Danish waters

Figure 4. Well-cutter, about 47 tons, engaged in Fishing and Transplantation of Plaice in the North Sea.

were entrusted with the work and they supplied, at a fixed price per kilo, the stipulated number of live plaice at the localities of liberation. Fishing craft caught the plaice in Nissum broad (western Limfjord), mostly with Danish seine; the fish were kept in well-boxes for at least two days before the transport in large well-boats or in a special basin cutter with artificial flow of water through eight closed basins. The well-boats transported about 4,000 kg., the basin cutter about 7,400 kg., as a maximum on each trip. The average size of the transplanted plaice was about 24 cm. in 1949 and 20 cm. in 1950; 2) in addition to these two methods of transport, well-cutters from Esbjerg (Fig. 4), ordinarily employed in live plaice fishing, caught plaice by Danish seine in the Horns Reef area and transported them directly (without first keeping them some time in well-boxes) to the localities of liberation on the eastern part of Dogger Bank. The cutters transported from 1,500 to 3,000 kg. on each trip to study the influence of size of load. The average size of the transplanted plaice was about 23 cm.

The sailing distance was at the most about 180 nautical miles and the distance was covered in less than 24 hours. The transport took place between 31. March and 19. May; it was mostly in April in 1950, but was later in 1949 owing to windy weather in April. April is the best month for transplantation owing to the low temperature. Less than about 3 % of the plaice died during the transport; two well-boats ran, however, into a storm and had a heavier loss.

The expenditure defrayed by the Danish Government was in 1949 about 100,000 Danish kroner for the transplantation of 978,000 live plaice (121.6 tons), in 1950 about 80,000 Danish kroner for 780,000 live plaice (67.5 tons). Each year about 15,000 Danish kroner were used for scientific control experiments, marking work, rewards for recaptured fish etc. Several experiments were carried out during fishing of the plaice, during storage in well-boxes and during transport to study, *inter alia*, the variation of oxygen pressure and its probable influence on fish condition. Moreover, successful transport by aeroplane was accomplished.

Marking of plaice at the liberation localities was carried out as a certain control on the transplantation experiments.

It is, however, very difficult to determine the actual result of a transplantation. The only possible control in this area is the marking of samples of transplanted plaice in localities scattered over the whole area. In 1949 about 4000 plaice, and in 1950 about 2800 plaice were marked and liberated. We do not know, however, whether the proportion of unmarked plaice recaught is the same as that of marked plaice, and so, from the percentage of recaptured marked plaice, we get only an estimate of the minimum surviving percentage of all transplanted plaice. Markings of local plaice on the Dogger Bank have been carried out simultaneously with transplantations and have given 60—70 % recaptures, but nearly all the locally marked plaice are over 27 cm., and are actually much larger than the plaice introduced, and it has been proved that the loss caused by the marking operation, enemies, illness, shedding of marks etc. is much heavier among fishes below ca. 23—24 cm. than among those over this size in the Dogger Bank area. So far we can only say that the recoveries of marked plaice show only the minimum percentage recovery (in number or weight) of all transplanted plaice; the actual benefit to the fishery must be higher.

The results from the marking experiments carried out show that the method of transport previously used in the Limfjord and in inner Danish waters

Figure 5. Localities on the Dogger Bank for Transplantation of Plaice in 1950. (Nos. 1—5).

was not at all a success in the Dogger Bank transplantations, and that—contrary to expectation—the transport by a basin cutter was a failure. The best method of transport was the well-cutters which, up to 14. April 1952, show average percentage recaptures of marked plaice of 14 % in number and of 48 % in weight for the 1949 experiment and of 14 % and 52 % respectively for the 1950 experiment; the growth in this area was, as usual, very good, and the average weight of all recaptured marked plaice was over 350 g. (average weight at liberation was only about 100 g.). By this cutter-method the transplantation has accordingly so far paid for itself. Various improvements should, however, be possible in the future.

Protection of the transplanted plaice in these international waters has not yet been possible, e. g. by increase of the minimum size-limit or by prohibition of the use of trawl or other gears at certain periods. The area where plaice were liberated is however principally a fishing ground for Danish seiners; about 90—95 % of all plaice recaptured there after the war were caught by Danish seine, and as this gear has a 120 mm. mesh in the cod-end the small plaice are actually protected to a certain degree for some time after the transplantation.

From the experiments so far carried out we have learned that the following factors are important during transplantations to the Dogger Bank: 1) the temperature should be low (< ca. 8—10° C.), *inter alia*, because the oxygen pressure in the well-boat falls too much at higher temperatures; the months March—April are accordingly the best; the economy necessitates, however, at least 2000—2500 kg. fish in each shipment; 2) too much wind and swell is detrimental, because the delicate small fish are tired out by moving and, moreover, they loose slime and the skin becomes chafed; 3) the larger the size of fish the better; best sizes are those over ca. 23 cm.; 4) the best method has proved to be fishing and direct transport (without storing in well-boxes) by well-cutters of 30—50 tons; 5) the fish should, as far as we know, principally be caught in localities where the stomach is not too full of shell fragments; 6) the load should not exceed 2000—2500 kg. in the well-cutters of the mentioned size; experiments with the smaller loads showed best results.

Following the successful transplantations to the Danish inner waters during 1928 and subsequent years, some **other countries** also commenced similar commercial experiments. In 1934 both Norway and Germany planned transplantations of plaice, Sweden began transplantations in 1935. During the years 1935—39 Sweden transplanted a total of 1,367,000 young plaice to west Swedish fjords, the Sound and the Baltic; 211,000—400,000 plaice were transplanted annually. The fish which had a size of about 17—22 cm., were obtained from Danish waters, viz. the Thyborøn area, and, to some extent, from the Esbjerg area. Best results were obtained in the deeper west Swedish fjords, the recapture percentage of marked transplanted plaice being 15 % or less. The growth in length and weight was very good. Plaice liberated in some fjords with shallow water soon left these waters. The transplantations to the Sound and the Baltic, comprising only 100,000 plaice were, however, of little succes. Norway and Sweden took shipments of young plaice from Danish coastal waters (e. g. off Thyborøn), and Germany transplanted plaice in lorries over land from Büsum to Kiel and Lübeck bays. In the years 1934—37 the following numbers of young plaice of a size of about 23—24 cm. were transplanted annually by Germany into the western Baltic: 160,000, 1,000,000, 500,000 and 600,000. The growth was very good and marked transplanted plaice gave good returns and few of the marked plaice left the area of liberation. As far as is known the last of these transplantations to the Baltic was carried out in 1938. Some smaller transplantation experiments were also carried out in the western Baltic, viz., in 1933 when plaice were transplanted from Rügen to Kiel Bay and in 1935 when some were taken from Oder Bank to Lübeck Bay. Some German fishery biologists, however, consider it hopeless for man to compete with Nature in this area and recently P. F. Meyer (1952) criticised the transplantations pointing out that much greater amounts should be transplanted than hitherto if the yield was to be of any general importance to the commercial fishery; he considered, moreover, that the present decrease of plaice stocks was caused by climatic changes. It is quite clear that transplantations are not at all remunerative in all areas; it is necessary to find out experimentally where it pays, and where not. Some west Swedish fjords are for instance not fit for transplanting because the transplanted plaice leave these fjords. Several localities in Danish waters have also given such low returns of transplanted plaice that transplantation there has been abandoned. Everybody involved agrees that in most places the numbers transplanted ought to be increased very much; this will be done gradually in some Danish waters, when better means to check the factors causing mortality of transplanted plaice have been acquired. In some waters the yield to the individual fisherman of transplanted plaice is of course negligible, as pointed out by Meyer for the western Baltic, but in others it is of great importance; as for example in the Limfjord where the plaice fishery takes third or fourth place among the different fisheries and where the transplanted plaice some years has supplied about 20 % or more of the total income of the plaice fishery.

Finding out whether a water is fit for transplantation is expensive and requires many years and much time; generalisation is impossible. It is of fundamental importance in all transplantation work of course that the expenses of fishing and transport should always be kept much less than the value of the yield that the transplanted fish can give to the fishery.

We will close this review on the plaice transplantations in recent years by mentioning, as one of

several small experimental transplantations of plaice, a very interesting experiment by R.S. Clark (1947), who in October 1937 transplanted 637 large plaice preparing to spawn from off the Scottish east coast (Firth of Forth) to the southern North Sea (Haisboro Lightvessel, off Norfolk). About 57% were recaptured, and the migrations were mainly to the north, some actually to near the home locality, and no recaptures were made in the chief spawning area in the Southern Bight though this area is very close to the locality of liberation. Such experiments ought to be continued owing to their interest for studies in "homing" and for the commercial transplantations.

Transplantation of other marine fishes has been carried out in north European waters only now and then as small scientific experiments; a rather large-scale experiment was however carried out at the proposal of H. Blegvad on cod in the Limfjord. The stock of cod there consists of immigrants from west or east, propagation inside the Limfjord being negligible. When immigration fails during a series of years cod are very scarce. It was proved (Poulsen 1942) that transplantation of young cod of a length of about 33 cm. (weight 330 g.) was remunerative there because growth is rapid (after one season the weight is about 1000 g.) and the percentage recapture is about 20%. In 1932, 1933 and 1934 respectively about 8000, 73,000 and 60,000 specimens of the length mentioned were transplanted in well-boats. As immigration of young cod was good again during the autumn 1935 the transplantation ceased and has not been continued later.

Intimately connected with transplantation of fish is propagation of fish. The hatched larvae or fry, which have been reared to a certain stage are actually nearly always transplanted to some other water than the home water of the parents. Hatching of marine fish larvae has previously been a very difficult procedure and few marine biologists have thought it possible for man on this line to compete with Nature outside very small waters. Recent propagation experiments on plaice by G. Rollefsen (1939, 1940, 1947) are however very promising though naturally several investigations of details are still required. The method of using *Artemia* nauplii as food for plaice larvae until metamorphosis is completed has shown that mortality under such conditions is negligible, and that bottom stages in millions are easily reared and could be liberated with success. It is accordingly possible that the present young plaice transplantations in more coastal areas must be abandoned at such a time when artificially reared young bottom stages can be produced by millions much more economically. In the open sea, as for instance in the Dogger Bank area, the youngest bottom stages cannot live, and here the only possibility is the transplantation of older stages.

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5.

Marking of Fish in Europe during 1927–1951.

By Árni Friðriksson

I. Introduction.

It is generally admitted that tagging or marking of fish is one of the most effective methods for the study of their biology, and there are some problems which can not be solved but by markings. The aim of marking experiments is to provide information on dispersion and movement of the fish, which in turn gives evidence of if there is a relationship between stocks or if they are independent of each other. Another important aim is to determine growth and to check age-determination made by other methods. The third main object is to investigate the size of the stocks through the rate of recaptures of tagged fish and the effect of fishing on the stocks of fish.

In this paper will be attempted a survey of the fish-marking carried out by the present member countries during the past 25 years. In some few cases, however, it has not been possible to secure complete information as to the number of fish marked, rate of returns etc. A mention will be made on the technical development in this field and an outline will be given of the work carried out and of the main results obtained.

In 1932 a "Guide to Fishmarks" was issued by the Council (Journ. du Cons., Vol. VII). As it has been decided to bring this valuable paper up to date in near future, description of fish marks and other information found there will not be dealt with here.

Finally it should be mentioned that some of the countries have in their surveys included markings made during the spring of 1952. Where this is the case, it will be pointed out.

II. Improvements in Technique.

Several experiments have been made in order to test the efficiency of different kinds of tags and tagging methods, the vitality of tagged fish, shedding of tags etc. As a consequence of the experience obtained, several new types of tags and new tagging methods have been introduced during the last 25 years. Attempts have been made to design special boats for tagging purposes and a quite successful craft of a new type (the "Harengus") has been used for herring taggings in Norway during two years. The "cradle" used in Sweden to keep herring in good condition during tagging has also been very successful. In 1935 a new salmon tag was introduced by Prof. Dahl, Norway, instead of the earlier used small silver tag, which had given returns of about 16 % only. By the new tag the returns increased to nearly 50 % and long-distance migrations of salmon could be recorded. During the years since the war the hydrostatic Lea tag has been used with increasing success and is now employed internationally in the tagging of salmon (smolts and adults), cod, mackerel, herring etc. The tag consists of a streamlined cylinder made of plastic or celluloid. The cylinder contains a short exterior text, informing the finder to remove the ends of the cylinder and read a letter inside. For the external tagging of herring another tag has been constructed by Aasen. It consists of a small cylindric roll of alcathine. Finally there is the Scottish toggle tag devised by Davis. It is made from two tapering or fish-shaped pieces of red polystyrene and is recommended for the tagging of driftnet- or trawl-caught herring onboard commercial fishing vessels, as the tagging can be executed by one man only.

As the greatest part of the herring catches in Norway and Iceland is converted to meal and oil in reduction plants, it was necessary to introduce internal tags for use by these countries for herring taggings. When a tagged herring is processed, the tag is caught by a separator-magnet. This method was invented by Rounsefell and Dahlgren, U. S. A., in the beginning of the thirties. In the early years, a team of four men could manage to tag 1000 herrings a day if conditions were favourable, but by means of the later devised tagging gun (invented by Aasen) a team of three can easily tag 2000-2500 during 8 hours.

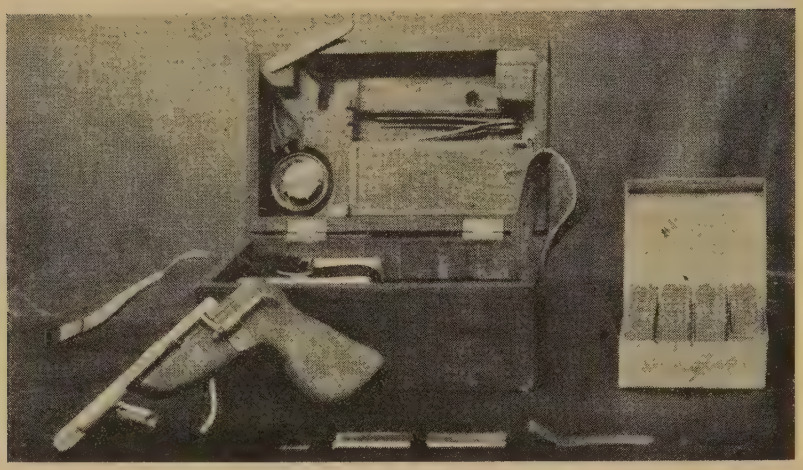

Figure 1. Outfit for internal tagging of Herring.
(Fot. KRISTFINNUR GUÐJÓNSSON).

III. Activities as to Countries.

1. Belgium. No taggings were carried out in Belgium during 1927—1951, but in early spring this year (1952) tagging of herring was commenced in co-operation with France. It is intended to be continued in the years to come.

2. Denmark. This country has tagged a greater number of fish through the period than any other country in Europe, or about 128,000 fish altogether. Intensive experiments have been made on plaice (abt. 73,200), cod (30,500), salmon (9,400), sea trout (7,100) and in recent years also herring (5,000). About 50,000 of the plaice have been tagged in connection with the transplantation experiments. The tagging scheme has also included species not dealt with by other countries as for instance Greenland halibut (1140) and Greenland shark (413). Markings have been executed in inner Danish waters, in the North Sea, at the Faroes, at Iceland, and at West and East Greenland.

3. England. This country ranges as number two having marked nearly 114,000 fish in the English Channel, the Irish Sea, and in the Atlantic (south of Ireland), the North Sea and in the Arctic Ocean. Of plaice alone more than 92,000 have been tagged, partly with the aim to provide data for the calculation of fish mortality, particularly that due to fishing. Large-scale experiments were also carried out on cod (4,600), dab (4,700) and sea trout (8,400).

4. Finland. Markings on salmon and some other species, for instance pike, were carried out during the period. Details as to the number of fish tagged etc. are, however, not available.

5. France. In 1931 France made taggings on hake in co-operation with England and in 1934 taggings of red mullet were carried out. Large-scale taggings on sardines were commenced in 1950 (4,950 fish during 1950—1951), and 1,600 herrings were tagged in 1951 and 1952, the last-named year in co-operation with Belgium (600 herrings). Furthermore nearly 3,000 salmon have been tagged.

6. Iceland. Until the war 1939—1945, Denmark took care of practically all taggings of fish in Icelandic waters. Since 1947, 1,600 salmon and 540 trout have been marked and since 1948 about 5,000 cod and 11,900 herrings have been marked. In addition to this, 700 plaice (1951) and 770 char (1937) were marked. The total number of tagged fish amounts to 20,400.

7. Ireland. Since 1948 some 1,950 salmon have been tagged. Marking experiments have also been made on escallop (*Pecten maximus*).

8. Netherlands. Taggings of carp have been carried out in the Lake Yssel.

9. Norway. Nearly 108,000 marine fish have been marked. Large-scale experiments have been carried out on herring (80,900) and cod (20,500). Besides this 2,600 mackerel, 2,900 plaice, and 850 halibut have been tagged. Successful experiments on salmon (and trout) have also been carried out but information about the number of fish liberated and returns is not available.

10. Portugal. During the years 1931—1938, 232 tunas were marked. As returns were poor (3 fish) the experiment was not continued.

11. Scotland. Taggings have been carried out in Icelandic and Faroe waters as well as in Scottish waters. The total number of fish tagged amounts to 56,500, excluding fresh water fish about which information has not been submitted. Besides that 980 lobsters have been marked. The tagging work has been concentrated on plaice (25,700), herring (16,300 since July 1948), and lemon sole (9,100) which also has been tagged at Iceland and the Faroes. It is worth to note that 3,200 haddocks have been successfully marked. 1,760 fish, which were marked in 1923 and 1925, are included in the total figure above.

12. Spain. No taggings have been carried out.

13. Sweden. The total number of marked fish amounts to 58,600. Large-scale markings have been made on 4 species: salmon (36,200), sea trout (5,900), plaice (7,500), and herring (5,000). The herring has partly been tagged in Swedish coastal waters, partly on the Fladen Ground.

IV. Markings and Returns in Different Waters according to Species.

In the appendix a survey is given of the number of fish tagged by species and, as far as possible, by areas. Following remarks have to be made.

The salmonids under the heading "Atlantic Coasts" have been marked by England and Ireland (1,945 salmon). No information on the number of salmonids tagged in Finland, Norway and Scotland has been submitted. The salmonids under the heading "Baltic" have been tagged in Sweden with exception of 80 salmon which were marked by Denmark in the open Baltic, and those under "Transition Area" have been marked in Denmark.

As may be seen from the appendix at least 33 species of fish have been tagged during the period, including as far as some countries are concerned the first 3-4 months of 1952. The total number of fish marked amounts to 504,566, but to this should be added the number of roach and bream marked in England, the salmonids from Finland, Scotland and Norway, the carps from the Netherlands and the hake and red mullet from France, and eel and pike from Finland.

After these words of introduction we will now consider the different species.

Figure 2. Migration of Herring between Iceland and Norway. (Friðriksson and Aasen, 1950).

1. Herring (*Clupea harengus*). Including the tagging in Norway during the spring of 1952, 120,222 herrings have been tagged altogether since the taggings were commenced in Norway and Iceland in 1948. Taggings have been made by Denmark, England, France and Belgium, Iceland, Norway, Scotland, and Sweden, external tags being used exclusively in all countries except Iceland and Norway. Some markings have, however, been carried out in Norway by means of external tags. The rate of returns has been very different for the different areas. In Scotland (North Sea and "Atlantic Coasts" (the Minch)) where five different types of tags have been used, the percentage of recoveries ranges between 0.1 and 3.2 %. From the English experiment in the Channel only 2 tags have been recovered. In Sweden 10.7 % of the herring tagged in coastal waters have been returned altogether (0.7 % from North Sea catches) and from the experiment in the North Sea 1.2 % was returned. The highest rates of returns have so far been recorded from the Danish experiments, especially when the Lea tags have been used. The total percentages from the different experiments run from 6.2 to 38.4. From the Danish experiments in the North Sea only 1.5 % were recovered. From the French experiment in 1951 (1000 herrings) and the French (and Belgian) one in 1952 (600) no returns have been reported. Finally, the extensive tagging experiments at Iceland, in the open North Atlantic and in Norway, have only given 1.05 % returns.

The results from the tagging experiments seem to indicate that the herring stocks of Europe are in no danger of being overfished for the time being with exception, perhaps, of the herring in inner Danish waters. But the most important knowledge so far obtained through the taggings, is the evidence of long-distance migrations of the herring. It has, for instance, been revealed that there is a close connection between the herring off the north coast of Iceland and the Norwegian winter herring, and between the herring in Skagerak and on the Fladen Ground.

2. Sardine (*Clupea pilchardus*). A 4,950 fish were tagged externally by France off the Atlantic coast of that country in 1950. Only 9 were recaptured near the tagging place shortly after tagging.

3. Mackerel (*Scomber scomber*). The only taggings of this fish took place in Norway in 1950 and 1951. 2,597 fish were liberated altogether, and 694 tags were returned (26.7 %). Most of the recaptures took place shortly after tagging and not far from the place of liberation. From an experiment near Bergen one specimen was, however, caught on the Fladen Ground 56 days after liberation, and some were taken in the eastern parts of Skagerak and Kattegat and one in the Baltic near Rügen.

4. Tuna (*Thunnus thynnus*). During 1931—1938, 232 fish were tagged by Portugal. Three specimens were returned not far from the place of tagging (max. 30 n.m.).

5. Cod (*Gadus callarias*). The total number of marked cod amounts to 60,941. The greatest part

Figure 3. Transoceanic migration of Cod.
(TÅNING, 1934).

has been liberated at West Greenland (20,957), Norway (18,041), Iceland (12,789), and in the Arctic Ocean (4,359). The participating countries were: Denmark (30,488), England (4,678), Iceland (4,959), Norway (20,520), and Sweden (857). In the Baltic (Sweden 1937—44) there is no indication of overfishing but considerable migrations within the area may take place. From experiments carried out in inner Danish waters in connection with transplantations, 25 % returns were recorded, and the corresponding figures for the Oslofjord (1935—38) and the Norwegian Skagerak coast (1937—39) are 29.0 % and 59.0 % respectively (Norway). In the North Sea (England) 6.3 % were recaptured. Off the west coast of Norway the rate of returns was found to be 19.3 % as a whole, and the total returns from the Lofoten area (LEA tags only) amount for the time being to 34.4 % of the number of fish liberated in 1947 and 44.2 % of the 1948-experiment. More returns from these experiments may be expected. In the Arctic Ocean English markings in 1937 revealed a recapture-rate of 3.8 % and the corresponding figure from a Norwegian experiment in 1947 (Spitzbergen) was 3.4 %. A large-scale experiment was made by the English at Spitzbergen in August-September of 1951, when 3,236 cod were marked, partly with PETERSEN buttons, partly with LEA tags. Up to the end of April this year, the PETERSEN buttons had given 3.4 % and the LEA tags 7.9 % returns. The markings at Lofoten and Spitzbergen have shown migration of cod between these areas and the track of migration is partly known in details. The recapture rate at the Faroes was found to be 20.5 %, and the Danish markings at Iceland have revealed a return rate of 12.9 % whereas the Icelandic markings have given a little lower figure (10.9 % for fish liberated in 1948). It is, however, to be kept in mind that much more returns may be expected from the Icelandic experiments, which commenced as late as in 1948. Returns from Greenland have proved to be 7.7 % for West Greenland and 2.7 % for East Greenland.

Quite many types of tags have been used for the marking of cod. The LEA tag has given the highest rate of recapture and has been the only tag in use in Norway since 1949.

The marking of cod has yielded very valuable information relating to:—

1) rate of recapture and the effect of fishing,
2) rate of growth and
3) migrations.

The rate of recapture has already been dealt with and the huge material now available has only been compiled partially as to rate of growth. The most important feature as regards the migrations are perhaps the large-scale movements of cod between Iceland and West Greenland in some years.

6. Saithe (*Gadus virens*). As can be seen from the appendix, only 104 saithe have been tagged (Denmark in Faroe waters), and 2 fish (1.9 %) have been recaptured. No information on the Norwegian marking of saithe in the 1930's has been submitted.

7. Haddock (*Gadus æglefinus*). With the exception of a few haddocks marked by Denmark (24) and England (107) Scotland is the only country which has carried out taggings of haddock. Since 1923 there have been tagged 3208 altogether by this country, 1760 in Scottish waters and 1448 at the Faroes. The rates of returns run as follows:—NE.-Scotland in 1923, 5.0 %; same area in 1925, 6.9 %; at the Faroes in 1950, 2.3 % and in the same area in 1951, 1.4 %.

8. Whiting (*Gadus merlangus*). Only 9 fish were tagged by England in the North Sea in 1939. No returns were recorded.

9. Hake (*Merluccius vulgaris*). In order to determine hake migrations, 70 fish were marked by England and France south of Ireland in August 1931. About 8½ months later, in April 1932, 1 fish was caught 130 n.m. from the place of marking. The increment in length amounted to 11.7 cm. as the fish grew from 28.9 up to 40.6 cm. 800 were marked in 1932, but yielded no returns.

10. Halibut (*Hippoglossus vulgaris*). Denmark has marked halibut at West Greenland (26), Iceland (221), and the Faroes (279), Scotland in the North Sea (62) and Norway in home waters (848). The returns have been as follows:—West Greenland 19.2 %, Iceland 12.2 %, Faroes 21.5 %, North Sea 19.4 %, and Norway 11.4 %. The markings have revealed long-distance migrations at least of young halibut, as for instance from the Faroe area to Iceland.

11. Greenland Halibut or **Blue Halibut** (*Reinhardtius hippoglossoides*). This arctic species has only been marked by Denmark in West Greenland waters (1140). The returns run to 14.9 %.

12. Plaice (*Pleuronectes platessa*). This important species has been marked in far greater number than any other fish in European waters, the total number liberated amounting to 202,035 individuals. The following six countries have carried out the markings:—Denmark (73,200), England (92,108), Iceland (700), Norway (2,903), Scotland (25,674), and Sweden (7,450). As far as can be seen, all the experiments have been carried out by means of PETERSEN marks of ebonite buttons attached by silver wire through the body of the fish. The most numerous markings have been carried out in the North Sea, but a great number of plaice has also been tagged in the Transition Area and the Irish Sea. This can be seen in Table 1, where details of all plaice taggings are given.

No information is available as to recaptures of the plaice marked in the Arctic Ocean. The markings in the Irish Sea took place between February 1945 and June 1951 and 39.5 % of the marked fish have been recaught so far. In the English Channel an experiment in 1926, which was carried out in connection with transplantations from the Dutch coast, yielded 19.8 % returns during the following years.

An interesting experiment was made in the Channel in 1929 in order to find out what type of fishing was most reducing to the stock of plaice in inshore waters. The trawling proved to be the most destructive one.

The rate of returns in Icelandic waters has proved to be 34.3 %, and about 30.0 % in Norway.

More than the half of all plaice taggings have been carried out in the North Sea by Denmark, England, and Scotland. Returns from Danish taggings were 23.3 % and Scottish taggings carried out 1947—1952 have yielded 23.6 % already. Scottish taggings in the north-western North Sea have shown that movements of the fish generally are northwards and westwards against the prevailing currents. The first big English experiment was carried out in 1929—1932 when 19,684 plaice were tagged in all, and 6,763 were recaptured up to and including the sixth year after liberation. There were 19 liberations and four places of liberation, at Jutland, the Frisian Coast, Heligoland, and the Haaks. The marked fish were mainly ranging between 18 and 21 cm. in length. The greatest part of the fish was recaught near the position of release and the dispersion in the first year was as great as in the subsequent years. There was mixing of fish from the different marking areas and

Table 1. Number of Plaice tagged by the various Countries in the different Areas.

Country	Arctic Ocean	Atlantic (Irish Sea)	English Channel	Iceland	North Sea	Norway	Trans. Area	Totals
Denmark	—	—	—	1,704	21,496	—	50,000[1])	73,200
England	103	31,437	3,293	—	57,275	—	—	92,108
Iceland	—	—	—	700	—	—	—	700
Norway	—	—	—	—	—	2,903	—	2,903
Scotland	—	—	—	—	25,674	—	—	25,674
Sweden	—	—	—	—	—	—	7,450	7,450
Totals	103	31,437	3,293	2,404	104,445	2,903	57,450	202,035

[1]) Approximately.

some penetrated into the Channel but none into the Kattegat. The rate of disappearance from all causes was 68—76 % per annum. There were far less returns of unmarketable sized fish, this loss probably being due to their being thrown away together with the useless part of the catches. Owing to this loss the rate of recaptures during the first year was found to be 39—55 %. In 1936—1937 a test was made on the vitality of trawl-caught plaice. A 918 fish were marked immediately and released, 546 were marked and released after having lain for one hour exposed on deck. The overall returns were 11.3 % and 9.7 % respectively showing that a fair proportion of plaice rejected on trawlers could survive. In October 1937, 637 plaice were transplanted from the Firth of Forth to the southern North Sea and marked before liberation. In all 67 % were recaught and some fish had migrated to Scottish waters and to the western part of the English Channel. In 1939 a large-scale experiment had been planned and 2,156 plaice had been marked before the outbreak of the war. About 11 % were recaptured later. The most important English marking was made in the southern North Sea in 1946, 1947, and 1948, when 33,708 plaice were marked altogether. Now 25.2 % (1946), 34.7 % (1947), and 26.6 % (1948) have been recaptured. It was found that the rate of recapture by British vessels (a) in the six statistical rectangles G and H, 3, 4 and 5 (11,575 fish liberated) and (b) in G 4 (6,717 fish) was as follows:—

Returns in	(a)	(b)
1st 37-days period	11.2 %	
2nd 37-days ,, ...	3.6 %	
3rd 37-days ,, ...	1.1 %	
1st 74-days ,, ...		12.2 %
2nd 74-days ,, ...		2.2 %

To determine rate of "sheddings" 516 plaice were liberated bearing two marks. In all 213 were recaptured, 193 bearing both tags and 20 (9.4 %) having shed one tag.

As shown in Table 1 about 57,450 plaice have been tagged by Denmark and Sweden in the Transition Area. Transplanted plaice and local plaice have been marked for comparison as to growth, survival, migration etc. In the Belt Sea 16 % of the transplanted plaice and 48 % of the local plaice, which had been marked, were recaught during the 1st year after liberation. Very few were recaptured later. The growth-increment in the first year after marking was found to be 12 cm. in the Limfjord and 8 cm. in the Belt Sea.

The extensive taggings of plaice have, all taken together, yielded the most valuable knowledge on growth, rate of mortality, effect of fishing, migration, and other biological features. The markings have shown that transplantation may be profitable which is reviewed in another contribution to this volume.

13. Dab (*Pleuronectes limanda*). More than 4,900 dabs (4,906) have been marked in the same way as plaice in the Irish Sea (3,088) and in the North Sea (1,818) by England (4,683) and Scotland (223). From the experiment in the Irish Sea (1949—1951) 368 fish or 12 % were returned. From the English (1946) and the Scottish markings in the North Sea 6.5 % and 23.8 % respectively have been recovered.

14. Lemon Sole (*Pleuronectes microcephalus*). Markings have been made at the Faroes (1,110), at Iceland (375) and in the North Sea (7,814) by Scotland (9,138), Denmark, and England. In all 9,299 fish have been marked. The rate of returns was found to be as follows:—North Sea 13.1 %, Faroes 9.6 % (Danish taggings) and 22.5 % (Scottish taggings), and Iceland 8.3 %.

15. Flounder (*Pleuronectes flesus*). Only 500 fish have been tagged by England and Scotland, in the Irish Sea (436) and in the North Sea. The returns total 13.6 % in the first-named place and 14.1 % in the other one.

16. Turbot (*Rhombus maximus*). The markings comprise 68 fish in the North Sea (England) and 210 in Danish waters. In the North Sea 13.3 % were returned and 20 % from an experiment in the Limfjord, all in the fjord.

17. Brill (*Rhombus laevis*). Of 53 fish liberated in the North Sea (England) in 1946, 4 have been recaught.

18. Megrim (*Zeugopterus megastoma*). Only one fish has been marked.

19. Sole (*Solea vulgaris*). During the great English marking experiment in the North Sea in 1939, 184 fish were tagged, and 6 have been recaught.

20. Salmon (*Salmo salar*). The total number of marked salmon amounts to 54,556. The following countries have carried out markings:—

Denmark . 9367	France... 2940	Norway.. ?
England . 2471	Iceland .. 1598	Scotland . ?
Finland .. ?	Ireland .. 1945	Sweden .. 36235

Unfortunately no information as to the number of tagged fish has been received from Finland, Norway, and Scotland.

Denmark. 8,300 $^1/_2$-year-old, 712 1-2-year-old, and 51 5-year-old fish, all being reared in ponds, were tagged in West Jutland. Furthermore 203 smolts and 21 kelts were marked. Information on returns is not available. Furthermore 80 line-caught salmon were marked in the open Baltic. 6 returns are on record.

England. In 1931, 291 salmon and 286 sea trout were marked at the estuary of the River Tees in order to study the effect of pollution on migrating fish. Of these 6 salmon and 6 trout were picked up dead in the estuary 1 to 9 days later. During 1947—1951, 167 adult salmon were marked using Lea tags. 33 fish or 19.8 % were recaptured. To study their mortality rate, 148 salmon kelts were marked by Lea tags in the River Dee, Wales, in 1947; 6 (4 %) were recovered. Finally, in 1952, 1,865 salmon kelts have been marked.

Figure 4. Long-distance migrations of Salmon.
(Dahl and Sømme, 1938).

France. In April 1951 and in March and April 1952, 960 and 1,980 migrating smolts were marked using Lea tags. Three were recovered after 22—27 days of liberation 650—750 km. from the place of marking. The minimum rate of speed must have been 27—29 km. in 24 hours on an average.

Iceland. In 1947, 401 smolts were marked by removing the adipose fin. 8.5 % returns have been recorded. Repeated experiments, partly using tags, gave 1.4 % returns from 1948 and none from 1949 and 1950. During 1948—1950, 622 kelts were tagged. 6.8 % have been recaptured.

Ireland. Tagging of clean salmon in the sea (1,533) has given from 20.6 % to 60.2 % returns from the different experiments. Long-distance migrations to the west and east coasts of Scotland have been found.

Sweden. Through 1930—1951, 36,235 salmon have been tagged in Sweden. The number of returns amounts to 2,904 (8 %).

Many different types of tags have been used for marking salmon, but during recent years the Lea hydrostatic tag has been adopted in more and more countries.

21. Sea Trout (*Salmo trutta*). Information is available from Denmark, England, Iceland, and Sweden, where 29,774 fish have been marked in all.

Denmark. During 1933—1938, 731 sea trout in different stages were marked in West Jutland and through 1948—1952 a great number has been added:— In Jutland 2,204 (2.8 % returns), in Seeland 4,001 (1.9 %) and in Bornholm 194 (0 %). The low return rates are partly due to the short time in liberty, so that many more recoveries may be expected.

England. During 1947—1949, 550 sea trout were marked with Lea tags in the sea off Whitby, Yorkshire. Of these 53 (9.7 %) have been recovered. In 1951 a large-scale experiment on sea trout tagging was commenced, when 7,473 smolts, 12 whitlings and 57 kelts were marked. The rate of returns has until now been 72 (0.9 %), 1 and 10 (17.6 %) respectively. In 1952, 7,102 smolts and 658 kelts have been marked.

Iceland. During 1947—1950, 540 smolts were marked by the removal of the adipose fin. No returns are on record.

Sweden. During the period 1935—1951, 5,938 sea trout were tagged. Of these 680 (11.5 %) have been returned.

22. Char (*Salvelinus* spp.). In West Greenland 14 were marked and 3 returned. In the Lake Thingvalla, Iceland, there is a small local form of char (*S. alpinus f. murta*). In 1937, 770 were marked and 16 (2.1 %) returns were reported. The markings, together with meristic studies, served to prove that this fish is a separate race.

23. Whitefish (*Coregonus lavaretus*). Markings were carried out in the Baltic (Sweden). Information on the number of marked and returned marked fish is

not available. The species is said to be rather stationary and the effect of fishing is considerable.

24. Catfish (*Anarrhichas lupus*). Of this species 131 were marked at Iceland (Denmark) and 36 (23.8 %) returned.

25. Eel (*Anguilla vulgaris*). Considerable markings have been carried out in the Baltic (Sweden and Finland). By comparing the results with those obtained by Estonia and Germany, one has got a good survey of the migration of silver eel out of the Baltic. The taggings have also shown the effect of winds and currents on the yield of the fisheries.

26. Pike (*Esox lucius*). Markings have been made by Finland and Sweden. They have revealed that this fish is very stationary and the rate of mortality owing to fishing is very high.

27. Red Mullet (*Mullus surmuletus*). Markings were made by France off the south coast of Bretagne in 1934. About 20 % were recaptured in 40 days. The increment of growth during 40 days was only 2 cm.

28. Carp (*Cyprinus* sp.). Taggings were made in the Lake Yssel, Netherlands. No information on number tagged and returned is available.

29. Roach (*Rutilus rutilus*). In 1936 a number were marked in the Northfolk Broads, England. No returns.

30. Bream (*Abramis* sp.). Also a number of this species was marked at the same place and time. No returns.

31. Greenland Shark (*Acanthorhinus carcharias*). Of this arctic fish 413 were marked in West Greenland waters. Of these 13 (3.1 %) have been recaught.

32. Skate (*Raja batis*). In 1939, 7 fish were marked in the North Sea (England) and 255 in Scottish waters. The last-mentioned experiment gave 80 returns (31.4 %).

33. Ray (*Raja clavata*). In England 7 were tagged in the North Sea, and in Scottish waters 606 fish were marked. Of these 164 or 27.1 % were returned.

Furthermore, 516 marked "Skate and Ray" were liberated in the North Sea during the big English experiments in 1946—1948. Of those 62 fish or 11.9 % have been recovered.

34. Shellfish.

Lobster (*Homarus vulgaris*). A 100 specimens were marked in the Limfjord, Denmark (1929), by means of incisions in the caudal fan. Recaptures within three years were 29 % and the largest migration noted about 4 n.m. Two experiments were made near the coast of Berwick, Northumberland, in 1950 (480) and 1951 (500) by Scotland. Recoveri'es amount to 112 (23.3 %) and 77 (15.4 %) respectively. The tag used is a numbered metal disc attached to one of the big claws. No migratory tendency has been observed so far.

Escallop (*Pecten maximus*). Taggings were made by Ireland. The tag used is a circular celluloid disc attached by means of a silver wire through a hole in the shell (1952). No results to date.

Clam (*Cyprina islandica*). Several hundreds were marked in Iceland in 1931—1932 by filing marks of different positions and directions in the shells. The few returns showed only a little migratory power.

In the appendix there is accounted for 504,033 tagged fish altogether. Even if we eliminate the few thousands from 1952, the total amount tagged is probably higher than this, most reasonably between 510—520 thousands. Tagging of fish has been much more stressed during recent years than earlier. Practically all the pelagic specimens 128,000 have been tagged during the last $4^1/_2$ years. Furthermore, at least 160,000 demersal fish have been tagged since the war, England alone having tagged 94—95 thousands and Sweden 35—36 thousands. This is an indication of the confidence the tagging method enjoys in modern marine sciences.

List of Publications.

Abbreviations used for the Council's own publications:—
R. P.-V. = Rapports et Procès-Verbaux. J. C. = Journal du Conseil. Ann. Biol. = Annales Biologiques.

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APPENDIX **Number of Fish tagged by present Member States during 1927–1951.**

Groups / Species	Arctic Ocean	Atlantic Coasts	Baltic	Channel	Faroes	W. Greenland	Iceland	North Sea	Norway	Trans. Area	Totals
Pelagic fish:											
Herring	—	935 2,518[1])	—	120	—	15	11,861	19,964	77,840	6,969	120,222
Sardine	—	4,950	—	—	—	—	—	—	—	—	4,950
Mackerel	—	—	—	—	—	—	—	—	2,597	—	2,597
Tuna	—	232	—	—	—	—	—	—	—	—	232
Cod fish:											
Cod	4,359	42	857	—	1,211	20,957 670[2])	12,789	287	18,041	1,728	60,941
Saithe	—	—	—	—	104	—	—	—	—	—	104
Haddock	104	—	—	—	1,448	—	24	1,763	—	—	3,339
Whiting	—	—	—	—	—	—	—	9	—	—	9
Hake	—	870	—	—	—	—	—	—	—	—	870
Flatfish:											
Halibut	—	—	—	—	279	26	221	62	848	—	1,436
Greenl. halibut	—	—	—	—	—	1,140	—	—	—	—	1,140
Plaice	103	31,437	—	3,293	—	—	2,404	104,445	2,903	57,450	202,035
Dab	—	3,088	—	—	—	—	—	1,818	—	—	4,906
Lemon sole	—	—	—	—	1,110	—	375	7,814	—	—	9,299
Flounder	—	436	—	—	—	—	—	64	—	—	500
Turbot	—	—	—	—	—	—	—	68	—	210	278
Brill	—	—	—	—	—	—	—	53	—	—	53
Megrim	—	—	—	—	—	—	—	1	—	—	1
Sole	—	—	—	—	—	—	—	184	—	—	184
Salmonidae:											
Salmon	—	7,356	36,315	—	—	—	1,598	—	+	9,287	54,556
Sea Trout	—	16,148	5,938	—	—	—	540	—	—	7,130	29,756
Char	—	—	—	—	—	14	770	—	—	—	784
Coregonus	—	—	400	—	—	—	—	—	—	—	400
Others:											
Catfish	—	—	—	—	1	—	151	—	—	—	152
Eel	—	—	2,375	—	—	—	—	—	—	—	2,375
Pike	—	—	400	—	—	—	—	—	—	—	400
Red Mullet	—	+	—	—	—	—	—	—	—	—	+
Carp	—	+	—	—	—	—	—	—	—	—	+
Roach	—	+	—	—	—	—	—	—	—	—	+
Bream	—	+	—	—	—	—	—	—	—	—	+
Greenland Shark	—	—	—	—	—	413	—	—	—	—	413
Skate	—	—	—	—	—	—	—	262	—	—	262
Ray	—	—	—	—	—	—	—	790	—	—	790
Skate and Ray	—	533	—	—	—	—	—	516	—	—	1,049
Total	4,566	66,027 2,518[1])	46,285	3,413	4,153	22,565 670[2])	30,733	138,100	102,229	82,774	504,033

[1]) Open N. Atlantic. [2]) E. Greenland.

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6.

La Détection des Bancs de Poissons.

Par Jean le Gall

Jusqu'à ces dernières années une expérience séculaire, seule, a permis aux pêcheurs, incapables de voir dans l'eau, de déceler par des signes extérieurs: vols d'oiseaux, couleur et odeur de l'eau, présence des bancs de poissons, se déplaçant en surface ou dans le voisinage, qu'ils savaient par routine ancestrale pouvoir trouver dans certaines régions à des époques bien déterminées.

Ces "apparences", parfois trompeuses, étaient pour eux un espoir de bonne pêche, confirmé, à l'occasion, par l'emploi d'un fil ténu, lesté, qui, lentement filé en profondeur, leur indiquait par ses vibrations le niveau auquel se tenait le banc repéré en surface par ces apparences extérieures.

Les recherches faites, depuis le début de ce siècle, dans les laboratoires maritimes spécialisés dans l'étude de la biologie et le comportement des poissons comestibles les plus importants pour l'économie de la pêche maritime, ont montré la valeur exacte de ces apparences et précisé les conditions hydrologiques du domaine géographique dans lequel se déplaçaient ces espèces ainsi que leur comportement dans ce milieu au cours de leurs déplacements saisonniers.

Les lieux de pêche de ces espèces aux différentes époques de l'année furent ainsi précisés, limitant les aires dans lesquelles la perspicacité des pêcheurs allait pouvoir, avec un espoir plus grand, se fier aux apparences routinières.

Les nombreux travaux publiés par le Conseil International depuis sa fondation et par les laboratoires maritimes contribuant à ses travaux ont fait état, à maintes reprises, des conditions du milieu externe comme de celles de l'état physiologique, c'est-à-dire du milieu interne des êtres marins régissant, d'une façon générale, les rassemblements et concentrations de poissons en surface comme en profondeur.

L'espace occupé aux époques d'apparition et de pêche de ces espèces ayant été précisé, la prospection rapide de ce domaine, parfois très vaste, était susceptible de renseigner utilement le pêcheur; les tentatives se multiplièrent au Danemark, en France, en Ecosse, en Norvège pour tenter de reconnaître en survolant à bord d'aéronefs (ballons d'observation, dirigeables, avions) les apparences de poissons visibles à la surface de l'eau et de déceler directement les bancs de poissons parfois visibles en eaux claires et peu profondes.

Les *Rapports et Procès-Verbaux* du Conseil International et les publications des services scientifiques des Etats membres du Conseil, antérieurs et postérieurs à 1927, ont relaté, à différentes reprises, les résultats généralement négatifs de ces essais de détection aérienne des bancs de poissons (harengs, maquereaux, sardines, etc. . . .), dus pour le plupart aux mauvaises conditions de visibilité fréquentes dans l'Atlantique nord-est et à la faible transparence de ses eaux littorales.

La détection aérienne des bancs de poissons (ou des Cétacés) n'a trouvé jusqu'ici d'applications pratiques que dans les eaux tropicales ou sub-tropicales du Pacifique où se pêchent la sardine et les thons et les petits poissons employés comme appât vivant pour leur pêche et dans les eaux antarctiques pour le repérage des baleines.

Avoir des yeux pour voir à distance les poissons dans l'eau tel restait le secret désir des savants pour mieux connaître le comportement des êtres vivants dans ce milieu inaccessible, comme celui des pêcheurs pour ne plus pêcher en se basant uniquement sur des apparences et pouvoir tendre leurs filets avec la certitude de faire de bonnes pêches.

Les deux dernières Guerres Mondiales ayant provoqué, dans un but militaire, des recherches sur la propagation des vibrations acoustiques dans l'eau de mer, puis la réalisation d'appareils de sondages et de détection des objets matériels se déplaçant dans l'air et dans l'eau, les services scientifiques des pêches maritimes y virent la possibilité d'appliquer ces découvertes récentes à la recherche de nouveaux fonds de pêche que déjà les premiers appareils de sondage, progressivement améliorés après la première guerre mondiale, avaient permis de découvrir, puis,

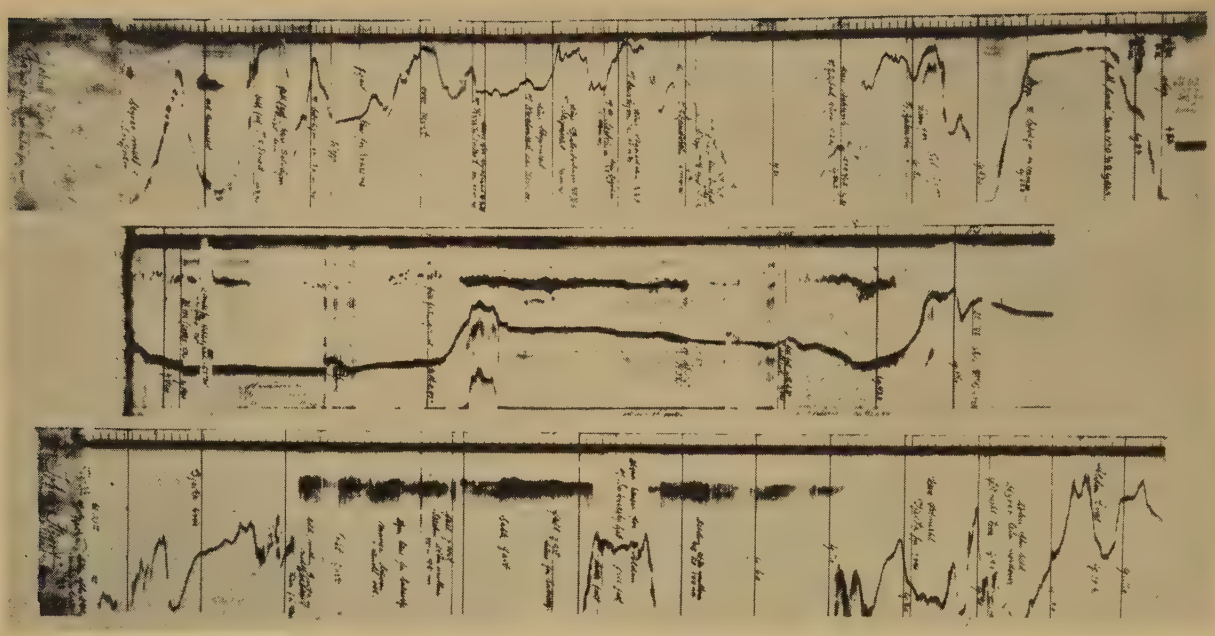

Figure 1. Trois échogrammes obtenus à bord du navire de recherches "Johan Hjort". (Réduit $^1/_6$, largeur originale 15 cm.)

a) De Sørfjorden, Gildeskål, Nordland, 3.II.1936, montrant, sur la gauche, à mi-profondeur 2 taches dûes à la présence de petits harengs.
b) De Høla — Lofoten, 1.IV.1935 — bancs de morues pondant.
c) De Aspøfjorden près de Florø — Norvège — 27.I.1936, montrant la présence abondante de grands harengs par 40—100 m. de profondeur.

Les marques sur le bord supérieur des diagrammes indiquent les minutes et correspondent à l'allure "Full Speed" (soit à environ 200 mètres dans cet instrument). La largeur extrême du papier correspond à environ 230 m.

à l'exploitation des bancs de poissons qu'un perfectionnement incessant de ces appareils, dû à l'application des résultats des nouvelles connaissances techniques dans le domaine de l'électronique, allait permettre de repérer avec précision dans ce milieu jusque là inaccessible à l'homme.

L'application des appareils de sondage et de détection des bancs de poissons par écho enregistré à la pêche maritime a été, depuis les temps les plus anciens, le progrès le plus sensationnel de l'industrie des pêches maritimes.

Il a été réalisé, grâce à la liaison constante qui s'est établie entre les constructeurs, les savants et les utilisateurs: navigateurs et pêcheurs.

L'emploi et l'amélioration progressifs de ces instruments ont marché de pair avec les connaissances acquises dans les laboratoires maritimes, les perfectionnements techniques réalisés dans leur construction et avec l'habitude acquise par l'expérience de leur emploi pour la pêche.

Le principe du sondage électronique plus connu sous le nom de sondage par l'écho (echo-sounding) est basé sur la propagation dans l'eau des vibrations accoustiques audibles et inaudibles quelle que soit leur longueur d'onde.

Ces ondes se propageant dans l'eau se réfléchissent contre l'obstacle qu'elles rencontrent. Elles reviennent ainsi, en écho, vers leur point d'émission, après avoir parcouru deux fois la distance qui sépare ce point de l'obstacle rencontré. Comme leur vitesse de transmission dans l'eau de mer est connue, il est possible de calculer la distance de l'obstacle ayant fait écho, si le temps très court qui sépare l'émission de la réception a été évalué.

Ceci est fait à l'aide d'appareils électroniques basés sur quelques principes différents qui enregistrent automatiquement le départ et le retour du train d'ondes.

Si l'émission est dirigée en faisceaux parallèles, horizontalement ou obliquement vers l'avant d'un navire et qu'un obstacle se présente sur son trajet, l'écho est enregistré à son retour et la distance à laquelle se trouve l'obstacle est automatiquement indiquée.

Le "Radar" détecte ainsi les obstacles dans l'air, et l'"Asdic" ceux se présentant dans l'eau dans le voisinage de la surface et en eaux profondes.

Si l'émission est dirigée verticalement du bateau vers le fond de la mer, c'est la profondeur de l'eau à cet endroit qui est indiquée; enfin, si, entre cet obstacle naturel, dont la présence apparaît nettement

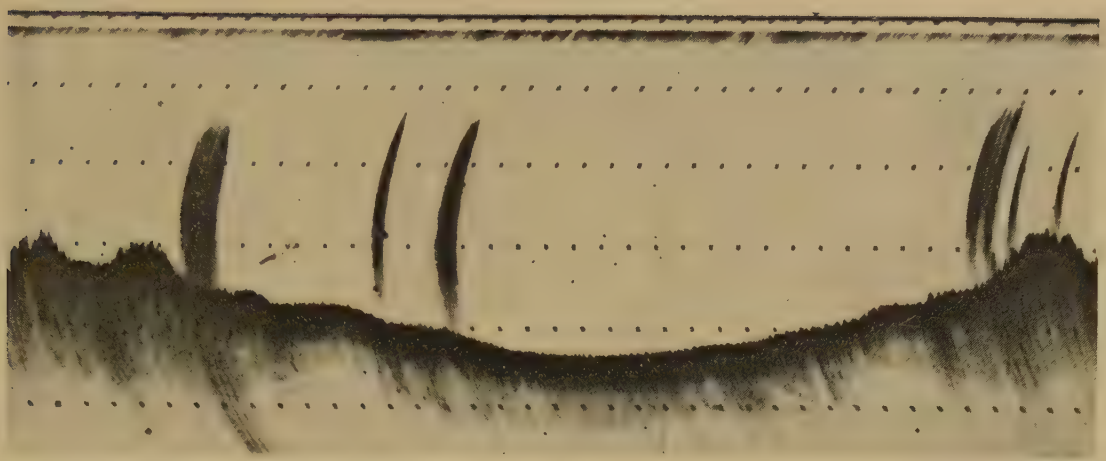

Figure 2. Une suite de bancs de sardines détectés par R/V "Onaway", sur la côte de Cornouailles. Notez le trait très dur du bord supérieur de la trace des bancs, qui est un fait typique de tous les échos de sardines.

sur l'enregistreur, un obstacle anormal vient à se présenter, entre la surface et le fond, sur le trajet du train d'ondes entretenues, un écho intermédiaire vient aussi s'inscrire sur l'enregistreur. Il décèle ainsi la profondeur et l'étendue de cet obstacle qui, si ce n'est un objet immergé, peut être un rassemblement de poissons ou d'autres organismes marins.

L'expérience a montré que les ondes sonores et ultra-sonores, d'une fréquence de 20 à 50,000 périodes par seconde étaient les meilleures pour déceler ces obstacles anormaux.

Elles traversent le milieu marin avec une vitesse de 1,500 mètres environ à la seconde et sont peu affectées par les variations de température et de salinité de l'eau.

L'expérience a montré encore que l'absorption partielle de l'énergie vibratoire était plus ou moins grande suivant la nature de l'obstacle rencontré, c'est-à-dire celle du fond et la consistance des sédiments qui le recouvre; l'écho réfléchi qui vient s'inscrire sur l'enregistreur est donc plus ou moins marqué, ce qui a permis de reconnaître la nature du fond et des objets enfouis.

Le sondeur acoustique d'abord, puis le sondeur électronique, ensuite, sont ainsi devenus des instruments précieux, non seulement pour la navigation courante, surtout pour celle dans les régions inexplorées, mais, également, pour le savant qu'ils renseignent sur la constitution du fond découvert, puis pour le pêcheur qui rapidement a su tirer les conclusions voulues pour reconnaître parmi les fonds détectés les fonds chalutables et éviter les obstacles anormaux se présentant devant son chalut.

De même l'absorption partielle de l'énergie sonique par les obstacles rencontrés dans l'eau (objets immergés, bancs de poissons et d'animaux marins) et la nature des échos enregistrés ont progressivement permis de détecter l'obstacle, de le situer en profondeur, d'en fixer l'étendue, et, en ce qui concerne les bancs de poissons, d'avoir une indication immédiate, précise, sur leur épaisseur, leur densité, puis, à mesure que les recherches s'intensifièrent, sur la nature même des espèces le constituant.

Les Ultra-Sons au Service de la Science et de la Pêche.

William C. Hodgson (1951) a fait l'historique de l'application du sondage par écho à la recherche scientifique et à la pêche et montré les progrès successivement réalisés depuis que le premier appareil du type sonique, utilisant des ondes sonores à basse fréquence audible, fut installé, en 1928, sur un chalutier anglais et, quelques années plus tôt — faut-il ajouter — sur plusieurs chalutiers français de grande pêche opérant sur les bancs de Terre-Neuve et au Groënland.

Dès 1926, R. Rallier du Baty, en mission à Terre-Neuve sur un de ces chalutiers, relevait la présence d'échos anormaux à l'enregistrement d'un sondage et l'attribuait à la présence d'un banc de morues. Le même fait était constaté deux ans plus tard à bord d'un drifter boulonnais pêchant aux abords du Dogger et attribué à des échos de harengs. Il devait l'être confirmé par la suite.

En 1930, un oscillateur piezo-quartz à ultra-sons, basé sur le principe Langevin-Florisson, avec enregistreur visuel, était mis en service sur un bateau de pêche. En 1933, l'enregistrement électrolytique de la profondeur sur un rouleau enregistreur avec un oscillateur ultra-sons à magnetostriction était réalisé.

Cette inscription permanente sur un papier des échos enregistrés recueillis par les navires de recherches et par les pêcheurs, interprétés et commentés dans

les laboratoires, adressés aux constructeurs de différents pays, allait conduire aux perfectionnements actuels de ces instruments et permettre à Oscar Sund, en 1935, d'utiliser sur la côte de Norvège, à bord du "Johan Hjort", cet appareil pour détecter avec certitude les bancs de morues dans la région des Lofoten, de les signaler aux pêcheurs, et, dès l'année suivante, de détecter de la même façon les bancs de harengs.

En 1937, Runnström l'utilisait pour étudier la distribution du hareng sur les côtes de Norvège.

Tester, en 1942, aidait de la même façon les seineurs de Vancouver à trouver les bancs de poissons qu'ils cherchaient.

Dès la fin des hostilités sur mer, les nouveaux progrès réalisés dans la construction des appareils, l'intérêt de plus en plus manifeste de ces moyens de sondage et de détection électronique des bancs de poissons, firent que les investigations se multiplièrent à bord des navires océanographiques et de recherches au Danemark, en Espagne, en France, en Grande-Bretagne (Angleterre et Ecosse), en Norvège, en Suède, au Pays-Bas et au Portugal, en un mot dans tous les Etats membres du Conseil. Elles firent l'objet de nombreuses communications dans les réunions des divers Comités du Conseil International et confirmèrent définitivement l'importance de ces appareils pour la recherche scientifique appliquée à la pêche, et tout spécialement pour celle-ci, quel que soit le mode pratiqué: filet dérivant ou senne tournante employés en surface ou à mi-profondeur pour la capture des poissons pélagiques, chaluts de types divers et senne danoise employés en profondeur ou sur le fond pour celle des espèces benthiques.

En 1950, W. C. Hodgson montrait, pour la première fois, que certaines espèces de poissons pouvaient être identifiées par la trace d'échos réfléchis inscrits sur la feuille d'enregistrement et décrivait les caractéristiques d'échos des bancs de harengs, de sardines, de sprats, de Gadidés.

De leur côté, Renou et Tchernia (1947) opérant avec un Asdic, constataient que l'écho, enregistré en phonie, variait suivant les espèces détectées et ils définissaient les échos sonores de bancs de sardines, de sprats, de harengs et de maquereaux.

Les bancs de poissons étant ainsi détectés, repérés dans leurs déplacements, reconnus quant à l'espèce qui les constituait, il devenait possible d'étudier le comportement du poisson vis-à-vis de certains facteurs du milieu (courants de marée, les vents, l'action de la lumière) également appréciables.

W. C. Hodgson (1951) montrait que le "choc" provoqué par les rayons lumineux d'un projecteur dirigé sur un banc de sardines, faisait descendre immédiatement ces poissons, qui, presque aussitôt remontaient vers la lumière, attirés par un phototropisme positif, pour redescendre dès que disparaissait la source lumineuse.

Devold, Wood et Hodgson, observant les migrations verticales diurnes et nocturnes des bancs de sprats, de harengs et les difficultés de les détecter en surface pendant le jour, en concluaient à un phototropisme négatif, déjà signalé pour le maquereau, le merlu par J. le Gall, les maintenant dans les couches

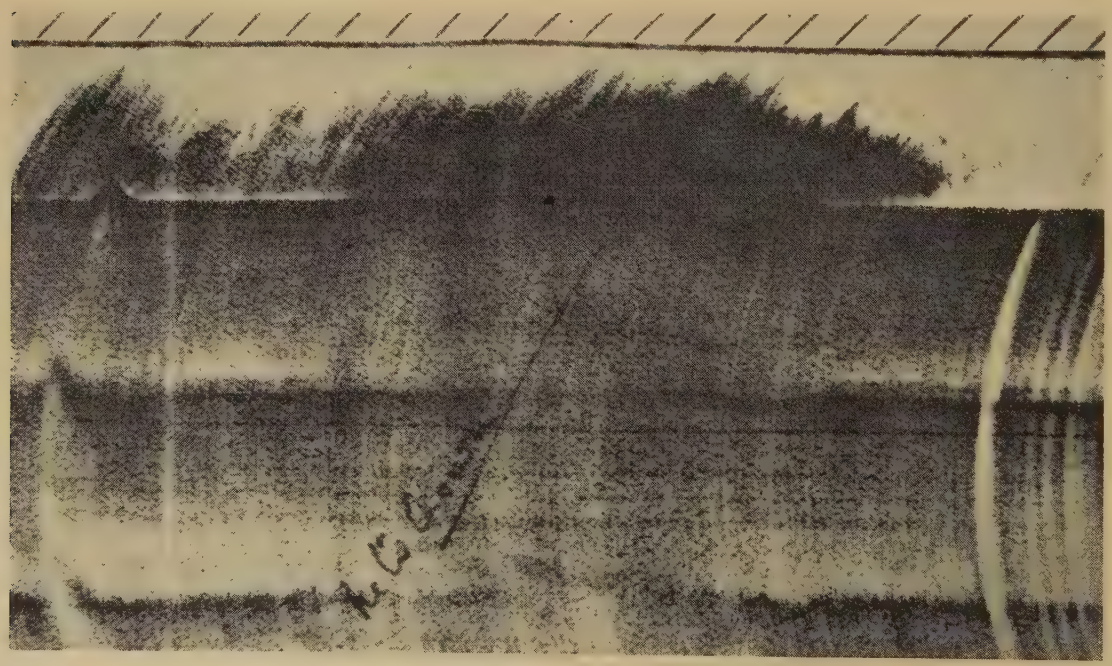

Figure 3. Trace typique d'un banc de hareng enregistré par un Drifter anglais.

Figure 4. Bancs de sprats enregistrés par R/V "Onaway" montrant la forme de comète, typique des petites traces de sprats.

profondes pendant le jour et facilitant leur ascension dès la tombée de la nuit et au cours de celle-ci, tandis que le phototropisme inverse de la sardine, qu'attire la lumière, fait que ce poisson "monte" pendant le jour, se disperse plus ou moins en surface jusqu'au soir et vient se rassembler pendant la nuit sur le fond où il se maintient jusqu'au lever du jour. Le phototropisme positif de ce poisson a également été constaté en France (ainsi que le phototropisme négatif du hareng et du sprat observés en Manche orientale, dans le sud de la Mer du Nord, dans le Golfe de Gascogne et sur les côtes du Maroc (J. FURNESTIN).

Les expériences de détection par echo-sounding (HODGSON), comme celles faites par Asdic (RENOU) ont montré encore que les bancs de Clupéidés (harengs, sprats et sardines) n'étaient pas toujours étendus, ainsi que le pensaient les pêcheurs, mais constitués par de petits groupes d'individus grégaires, de 7 à 45 mètres de diamètre, qui se rassemblaient en concentrations beaucoup plus importantes suivant les conditions statiques ou dynamiques du milieu extérieur et aussi suivant l'état physiologique des poissons. L'influence des courants de marée, de la lune, de la profondeur des eaux sur la concentration et la dispersion des bancs de sprats et de harengs pendant les périodes de vives eaux ou de mortes eaux a été mise ainsi en évidence (R. BALLS).

Une meilleure connaissance du comportement du poisson dans son milieu une fois acquise, l'attention des chercheurs se porta également sur le fonctionnement dans l'eau des engins destinés à le capturer.

WOOD et PARRISH (1951) ont fait des constatations extrêmement intéressantes et d'un intérêt pratique évident sur le comportement du chalut en action. Ces observations sont actuellement poursuivies en Grande-Bretagne, en Norvège, en Allemagne et dans d'autres pays.

De cette collaboration constante entre producteurs: techniciens et constructeurs et utilisateurs, savants et pêcheurs, sont nés différents types d'appareils de sondage électronique, spécialement construits pour la détection des bancs de poissons, indiquant instantanément et clairement, grâce à des dispositifs perfectionnés d'enregistrement mécanique, électrolytique ou optique, la présence des bancs de poissons.

A côté de ces appareils, conçus pour la grande pêche et la pêche hauturière, les constructeurs se sont penchés également sur la réalisation d'un type d'appareil simple et rustique, convenant aux bateaux de faible tonnage, généralement construits en bois, pratiquant la pêche artisanale des poissons saisonniers dans les eaux littorales peu profondes et dont un oscillateur serait installé à bord dans les conditions habituelles, ou à l'extérieur, dans une coquille remorquée, pour éviter de percer la coque pour sa fixation.

La réalisation de cet appareil multiplierait encore le champ d'application du sondage par écho à la pêche.

Cependant, ces appareils de sondage par écho ne peuvent détecter que les bancs de poisson se présentant dans l'eau à la verticale du bateau, donc dans un rayon limité autour du point d'émission. L'Asdic permet, de son côté, une prospection horizontale ou légèrement oblique autour du bateau. Les deux instruments se complètent et coexistent généralement sur les navires de recherches.

L'application de l'Asdic à la détection des bancs de poisson a donné de bons résultats, mais des recherches sont encore nécessaires pour la réalisation d'un instrument robuste, simple, pouvant être mis entre les mains des pêcheurs.

C'est dans cet esprit que le Conseil International — dont les experts suivent attentivement ces travaux, à la suite d'une recommandation du Comité du Nord-Ouest, reconnaissant que le sondage électronique Asdic est important pour détecter et prospecter les bancs de harengs et autres poissons — faisait savoir, au cours de sa dernière Assemblée plénière en 1951, aux Etats membres du Conseil, qu'ils seraient bien avisés d'équiper leurs navires de recherches avec cet appareil et il chargeait le Président du Comité du Hareng de recueillir près des experts du Conseil leurs conceptions actuelles, résultats de leurs expériences, pour une meilleure utilisation des sondeurs à écho et de l'Asdic pour la détection des bancs de poissons, ceci dans le but d'établir un document préparé à l'intention des constructeurs qui seraient invités à compléter les informations connues sur ces instruments et à tenir compte des désirs des savants spécialisés — et des professionnels avec qui ils se trouvent en contact — pour leur perfectionnement en vue d'une meilleure détection des bancs de poissons et la possibilité de condenser en un seul appareil les éléments essentiels de l'Asdic et du sondeur vertical par écho pour réaliser, enfin, l'œil électrique qui pourrait scruter de tous côtés.

Détection Optique.

Découvrir la présence réelle du poisson, pouvoir enregistrer ses déplacements, est déjà un progrès énorme sur les moyens empiriques employés jusqu'à ces dernières années pour reconnaître sa présence possible. Cependant, cette détection acoustique ne peut encore se flatter de remplacer l'œil humain.

Or, le pêcheur comme le savant voudraient voir dans ce milieu, qui leur reste encore inaccessible malgré l'emploi du scaphandre léger à rayon d'action limité, les poissons et autres animaux marins qui s'y trouvent être chez eux.

Les recherches intensives faites après la perte du sous-marin anglais "Affray", coulé en Manche en 1950 et dont l'épave fut découverte grâce au sondeur, mais restait à identifier, se traduisirent par la réalisation d'une unité de télévision sous-marine, basée sur l'emploi de cellules photo-électriques qui permit d'identifier avec certitude le sous-marin dont l'image du kiosque se reflétait sur un écran.

L'emploi de la cellule photo-électrique pour la vision sous-marine n'était pas une idée neuve. Le Dr. Hartmann, en 1932, avait déjà réalisé un téléviseur sous-marin qui, descendu dans les profondeurs, devait permettre de poursuivre sans fatigue les plus difficiles des explorations sous-marines, en faisant défiler sur un écran les images recueillies en profondeur, et, à cette époque, J. le Gall avait déjà souligné l'importance de cette découverte dans le domaine des recherches océanographiques et dans celui de la pêche.

La Marconi Wireless Telegraph Co., qui réalisa l'appareil de télévision sous-marine ayant permit de reconnaître le sous-marin "Affray", a compris que cet appareil pouvait avoir une influence profonde sur l'avenir des recherches océanographiques pures et appliquées et sur la pêche. Elle poursuit, en collaboration avec les laboratoires maritimes de Grande-Bretagne, la mise au point d'un appareil de télévision. De cette collaboration étroite qui s'est établie entre les techniciens anglais et les laboratoires scientifiques des pêches maritimes, doit résulter un premier appareil qui pourra être mis prochainement en essai.

Cet appareil n'est pas destiné à remplacer les appareils de détection acoustique actuellement en service, mais à les compléter en rendant visible la vie sous-marine à des profondeurs telles qu'il serait impossible à l'œil humain de la discerner et d'identifier ainsi les poissons précédemment détectés au sondeur U. S.

Il apportera certainement une aide précieuse aux savants dans leurs travaux de biologie marine appliquée à la pêche et aussi aux pêcheurs qui pourront désormais suivre de leur passerelle les évolutions du banc de poisson détecté et le fonctionnement de l'engin destiné à les capturer.

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7.

Overfishing and Optimum Fishing.

By Michael Graham

The quarter century from 1928 to 1952 almost exactly covered two developments towards optimum fishing, operating in parallel. The first was international action to make the basic level of stock secure, the second was one which it is convenient to treat as the major theme of this paper, the development of the theory of fishing, from a vaguely logical statement to a precise mathematical formulation that can be used for scientific estimates.

An exception to the claim that all development of theory took place between 1928 and 1952 was provided by the formulation of Baranov (1918) which was overlooked until its significance was noted by W. F. Thompson (1937). Baranov approached the formulation in the way that is now generally agreed, in terms of the yield of a single year-class of fish as it lives through that part of its life history where it is vulnerable to fishing. He observed that the yield would be the nett result of growth tending to increase the yield and mortality tending to decrease it; and he stated a differential equation from which the effect of these processes could be derived. We must, therefore, honour fully the pioneer work of Baranov and acknowledge the error of fishery scientists in failing to notice at the time the significance of his paper, namely that it was the first attempt to arrive at a mathematical formulation of a theory of fishing, and was on perfectly sound lines. An example of his formulation is illustrated by the upper curve of Figure 1.

In the background of the International Council's thinking on the subject, was the guidance of Petersen (1894) who, in words, had formulated the correct approach to a first approximate statement of the theory of fishing. "For it cannot well be doubted that the same area of sea would be able to give a quantitatively greater profit as a constancy, when we suffered the stock of fish to be as fully developed, as in the years before the too eager fishing commenced, ... and then took exactly so much as the stock could reproduce by new growth".

The Council has always been active on this subject, as is evidenced especially by the work of Commission B in the first decade of this century, but no advance

Figure 1. Baranov's curve above and Beverton and Holt's curve below.

on Petersen's theory was made until 1931, when the first paper to be noted in the quarter century under review was published by Russell. This was studiously modest in its presentation, yet its aim was high: namely to state, in quite simple yet quantitative terms, the processes contributing to a steady yield from a steady fishery. As with so many important and original papers, the statements, once they had been made and presented in isolation from disturbing ideas derived from second-order processes, appeared completely self-evident: "Those elementary principles that are at the back of everyone's mind" (Russell, p. 3, 1931). Indeed Meek (1930) had just given a graphical representation covering the question fairly well.

Russell evidently did not realize how important his achievement was. He had reached a formulation clear of fluctuations in brood-strength, that is, considering the average yield over the course of years, or the fishing rate that will make the best use of a brood within a certain range of natural fluctuations. The concept of equilibrium between stock increase and removals by fishing was an important contribution by Russell. A further simplification was the conception of fishable stock,

replenished by recruits of total weight A in a year, all fish below a given size being considered unfishable.

With a stock in equilibrium, the annual sums of four processes tending to change its weight must, he pointed out, conform to this equation

$$A + G = C + M$$

where A is the increment due to the total weight of recruits, G the corresponding growth increment, M the total loss of weight by mortality, and C the weight caught.

Because A, G, and M can be higher or lower, C can be higher or lower, thus maintaining equilibrium at various levels. But RUSSELL was much disturbed by the interaction of the vital processes with each other, a question that he discussed clearly and comprehensively; and which appeared to preclude rapid progress on the application of his theory.

Not long after the publication of RUSSELL's paper HJORT and his colleagues made as it were an independent attack on the theoretical problem of the yield of a living population, namely the whales (HJORT, JAHN, and OTTESTAD, 1933). With the background of the knowledge of these and other fisheries, they saw that theory must provide for an *optimum catch* at some intermediate level of fishing, neither so low that no animals were caught, nor so high that none were allowed to grow and breed. Their formulation used the "auto-catalytic" law of organisms growing in a limited medium, where there would be a maximum rate of natural increase at some intermediate density of population, which state would, therefore, seem to provide something like the best yield to be obtained.

Figure 2 illustrates the law of HJORT *et al.*

It is to be noted that the theory of HJORT *et al.* is related to that of RUSSELL in the following manner. If it is assumed that the states represented by all points on their sigmoid curve are attainable, by increasing fishing or by reducing it, and so changing the average population density and its average age at will, then a state near the point of inflexion can be attained and maintained, which might well be the aim of fishery regulation. At that point maximum steady yield = maximum rate of natural increase or, in RUSSELL's notation, neglecting certain mathematical niceties,

$$C_{\max.} = (A + G - M)_{\max.}$$

But at any other point, RUSSELL's equation could equally well be applied

$$C_r = (A + G - M)_r$$

from which we see that the theory of HJORT *et al* included all states of the processes represented by RUSSELL's A, G and M, and all the interactions between them that prevented RUSSELL applying his equation to actual data.

Unfortunately, however, the parameters of the equation of HJORT *et al.* are not readily obtainable for populations of fish, nor of whales. In order to fit these curves to data, it is necessary to have knowledge of the yield and population density under several steady states of fishing.

It is interesting that the absence of a usable mathematical theory has never deterred investigators from bringing to light conditions in particular fisheries that appeared to indicate overfishing. The quarter century earlier than the one under review saw many examples of these "common sense" appraisements of situations as requiring remedy, coupled with scientific evidence in support of conservation, so far as it went.

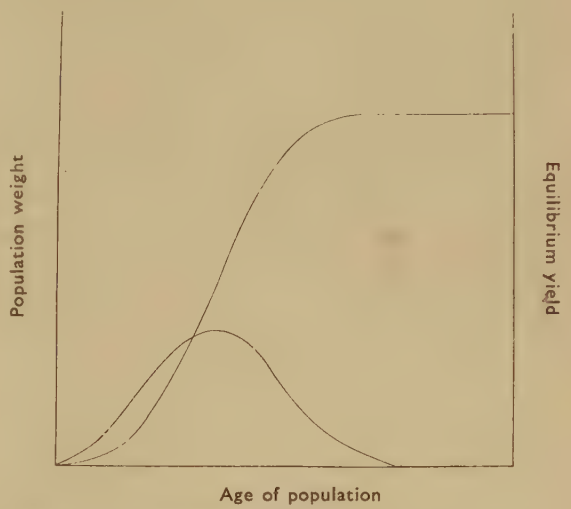

Figure 2. The formulation of HJORT, JAHN and OTTESTAD, with the curve of stock (population weight) above and that of yield (the first derivate of that of stock) below.

A notable achievement in this class led to the treaty of 1929 between the countries interested in the Baltic fisheries, and the studies that supported it (e. g. MOLANDER, 1932; and see MEYER, 1951). Indeed the period under review opened with the greatest of these movements well under way, that leading to the International Convention of 1937 on mesh of nets and on size limits.

Already, in some countries, size limits had been in force for some years; and since 1933 there had been regulation of mesh in Great Britain. The regulations in force in 1934 are given in detail on pp. 6–13 of the report of the Special Biological Meeting in that year. For delicate fish such as haddock size limits alone could not prevent the death of undersized fish: the cure would be to avoid catching them. Plaice are hardier, and the size caught is usually a function of depth, and therefore partly under the fisherman's control: but for the haddock no other measure than the use of a larger mesh held out any promise of improvement.

It was clear that the time was approaching for extending conservation measures to include regulation of mesh internationally, and the Council sponsored

research directed to elucidate some of the points in doubt. In reviewing this movement it will be necessary to cover briefly the ground of FORD's Buckland lectures (1937), which is almost a contemporary account, written with the freshness suitable to recent and exciting events.

There was first the question of whether it would in fact pay to spare the undersized fish. Were there not millions of them? It was held by some people that if these were "thinned", as one thins seedlings, they would grow faster, which was undoubtedly true; but the question really was this, "Would the increased growth compensate for the fewer numbers?" This question was considered at a Special Meeting of the Council in 1932, and the answer was a negative. RUSSELL used data of DAWES (1930–31) to show that it would take about 2 years for the food spared by the thinning of the stock to be converted to flesh in the survivors, so that, at best, it would not pay to thin fish within two years of becoming of marketable age. BÜCKMANN used a model, based on the severe assumption that growth-rate was inversely proportional to population density, and reached a like conclusion.

The conclusions of the meeting in 1932 made reasonable the general anxiety at the destruction of millions of undersized flatfish along the German and Flemish coasts, expressed by WULFF and BÜCKMANN (1932) and GILSON (1935). The small fish were being taken for feeding ducks or for fish-meal or incidentally in shrimping. But more serious, according to both RUSSELL and BÜCKMANN, because nearer marketable size, were the quantities of haddock rejected dead at sea, as reported by BOWMAN at the Special Meeting (1932).

The other difficulties requiring investigation were in the action of the trawl itself. FULTON (1894), REDEKE (1906), and TODD (1911) had covered parts of the trawl with fine-meshed netting and so had investigated what sizes of fish had passed through the mesh of the main trawl. A "saving" trawl, invented by Captain RIDDERSTAD (1915) had been tried but found ineffective (DAVIS, Special Meeting, 1934). Another "saving" trawl, the Gelder, was under test; but by 1929 expert opinion, led in the first instance by some remarks in 1924 of Captain GRIMWOOD, fishing skipper of the "George Bligh", had turned to the question of enlarging the meshes of the cod-end of the ordinary trawl. Thus the reports submitted to the "Savings Gear Committee" in 1929 included some on special gear, and some on tests of meshes of different sizes. RUSSELL and EDSER (1926) had already described part of a serious attack on the problems of escape through various meshes; WOLLASTON (1927) had formulated a mathematical theory for defining the selective action of a net. Now, at the opening of the period under review, BOWMAN (1928) compared sizes of catch with sizes of mesh, and trawls with seines. BOROWIK (1930) showed that the commercial gear "sifted" the fish, and WOLLASTON (1929) compared selective actions of different nets.

The activities under the Council leading to mesh regulation were brought together at the Special Meeting of 1934, the report of which serves to show everything needful. The two points that it was necessary to agree on were, (1) that it is desirable to spare undersized fish, especially those that are approaching a commercially valuable size, (2) that it is practicable to do so, at least for roundfish, by increasing the mesh of the nets used. Point (1) had been agreed at the Special Meeting of 1932; on Point (2) new evidence was brought by DAVIS, by IVERSEN, by CLARK, and by ANDERSSON. DAVIS first reviewed the question of "saving" gear, rejecting special designs and outlining the English experiments on simple enlargement of mesh. Then he reported a test to prove that fish did escape during towing of the trawl, not only, as had been averred for many decades, at the end of a haul when many would be dead or seriously damaged. Finally, he reported on a trial on a commercial scale in which the yields, principally of haddock, were approximately equal in money, although two different meshes (24 rows per yard and 21 rows per yard, when fishing) had been used. The loss of smaller fish by the larger mesh was made up for by greater catches of larger fish, even on this overfished population where larger fish were scarcer than they would be in a population which had had the benefit of being fished very regularly by the larger mesh.

Other writers, and all the Area Committees, supported the idea of international mesh regulation, and the Meeting had no difficulty in recommending general adoption of the minimum mesh in force in the United Kingdom, namely approximately a 3-inch mesh, measured from inside one knot to outside the opposite knot when the mesh is pulled taut lengthwise. This regulation was designed particularly to protect the haddock, and should, the meeting thought, be supported by a size limit, which would serve to enforce use of the correct mesh. For flatfish such a small minimum mesh would make no effective improvement, and the meeting recommended proceeding by a size limit. It is to be borne in mind that flatfish can survive capture if followed by speedy return to the sea (Fisheries Notice No. 25).

From 23.–28. November 1936, an international conference met in London and concluded that there was a sufficient degree of unanimity on the necessity for mesh regulation and size limits for a draft convention to be prepared, and at a further conference, also held in London, on 17.–23. March 1937, such a Convention was signed by delegates of ten countries. A mesh of 105 mm. on the gauge was adopted for waters which are both north of 66° N. Lat. and east of the meridian of Greenwich, which excluded Greenland, Iceland and Faroe; and a mesh of 70 mm. for all the other "dependent seas" of the North Atlantic including the areas just mentioned. Size limits were adopted for 10 species, including hake 30 cm., haddock 24 cm., plaice 23 cm., overall length. Neither the mesh regulations nor the size limits represented any sub-

stantial advance towards the optimum fishing, their value lay in that they formed a start.

The Convention of 1937 was superseded by that of 1946, in which the mesh for distant waters, now including Icelandic grounds, was raised to 110 mm. and in all other waters covered by the Convention, that is from 48° northwards and from Cape Farewell to Vardø, the mesh was to be 80 mm. on the gauge. In addition a Permanent Commission was constituted, for consideration of extensions or alterations of the provisions of the Convention. Size limits were also raised, and two more species (*G. merlangus* and *P. limanda*) were added to the list, which now included hake 30 cm., haddock 27 cm., plaice 25 cm.

It is evident that such advances in comprehensive thinking as were being made between 1930 and 1935 were accompanied by vigorous prosecution of conservation policy, based on partial assessment of the situation, but, nevertheless, sound. The overfished condition of the North Sea was indeed so obvious, that no very advanced theory was required to justify the first modest measure of conservation. In somewhat the same way, on the other side of the globe, the beginning of the period under review saw the outstanding, indeed the classical example of regulation somewhat in advance of full mathematical theory undertaken on a large scale. This was the regulation of the halibut fishery of the Pacific, which began effectively in 1930 with the simple ordinance that the annual catch in future should not exceed two specified quantities, for two different areas.

It would be false, however, to think that Thompson and Bell (1934) had recommended regulatory action without a clear conception of the theory of the yield of halibut, which, in fact was entirely in keeping with that of Russell. Their method was to put in trial but reasonable values of fishing and yield in several imaginary models, and to adopt the values that gave the best fit to the past history of the fishery, and so to predict its future course under regulation. This has been successful, the reduced effort finally allowing even an increased total yield, although with some complications arising partly from the form of the regulation (Report of General Meeting 1951).

The problems of the halibut fishery in the Pacific are outside the scope of the present review, but Thompson and Bell's paper is relevant to this extent, that it encouraged European workers not to be too much deterred by second-order considerations, but, in the presence of widespread distress among North Sea trawl fishermen, to attempt, by hook or by crook, to assess the state of the North Sea stocks: on the basis of Russell's formulation or even of Hjort's. The first paper in this movement was that of Graham (1935) followed by a new approach to the problems of growth, in a Special Meeting of the Council (1938), then by Russell's lectures published later in book form (1942), and by the papers at the Special Meeting in 1939. This movement from 1935 to 1939, with its fruits in the International Conference of 1947, was the principal new activity of the Council under the heading of Overfishing during the period under review. The papers written in that period represented the adoption of Russell's formulation in theory, and opened the way for its adoption in practice. They are, therefore, on several counts worth some attention in the present review.

Graham (1935) would claim that his paper called attention to the "peculiar attraction of the modern theory, that the benefit of efficient exploitation lies more in *economy of effort* than in increase of yield, or preservation of future stocks, though both of these purposes may also be served" (1935 p. 264). Thus an estimate of the maximum yield of all species from the North Sea made it 15 % above the overfished yield, but the economy of effort was estimated at 25 %.

The "new" theory therefore returned to Petersen's statement, in that it offered a valuable prize within a year or two of the start of regulation, namely *increased profit*. But, in order to take this benefit fully, it is necessary for the regulation itself to be economical. Thus merely to make fishing operations 25 % less effective, as by returning to an obsolete form of trawl, would yield the extra 15 % in weight of fish, so increasing the catch per cost by roughly 15 %; but this would not be so profitable as removing from the overfished stocks 25 % of the fishing time, which would save 25 % of the running expenses, so increasing the catch per cost by approximately $^{115}/_{75}$–1 or 53 %.

The Council's Special Meeting of 1939, referred to above, was concerned with evidence from nine authors on the necessity of a decrease in intensity of fishing; and there was virtual unanimity on that point. But the circumstances of that meeting, in Berlin in May 1939, appear not to have been conducive to orderly and integrated discussion, such as had taken place at the meeting in 1934 on mesh regulation. Certainly the lesson of profitableness does not come clearly out of reading the report. It is therefore hardly surprising that the British proposal at the Conference of 1946, to agree on a reduced global tonnage of vessels engaged in demersal fishing, appeared to many delegates to be premature. The Conference was, however, able to agree, with certain serious reservations by several countries, that there was a case for "some international control of fishing effort, mainly in the North Sea".

This question was taken up again at Conferences in London in January and in April 1947, but no further progress was made towards agreement on the British proposal. Instead the Conference saw "substantial and practical objection to the rigid application of the same scheme in every country". For the next two years, it was recommended that each country should take such action as suited it, to an extent that would make the various actions roughly equivalent as conservation measures. Thus, Norway could adopt a close season, Sweden and Denmark could use larger meshes than the other countries, the United Kingdom could limit her

tonnage, and the Netherlands her total catch. It was also agreed that there would have to be supporting regulations in each country to make the measure adopted really effective in conservation. Furthermore, it was recommended to set up an International Commission to take under annual review the fishing activity in the North Sea from the point of view of conservation of the stocks, and to report thereon to the Governments concerned.

In October 1947 the Council held a Special Meeting on the Effect of the War on the Stocks of Commercial Fishes. The proceedings were arranged so as to give ample opportunity for disagreement on the meaning of the evidence, but there was complete agreement. For one stock—that of the Arcto-Norwegian cod—it was apparent that the reduction of fishing during the war period did not cause the changes observed in the yield. In the Swedish fishery for witches there was room for some doubt; but "in all other fisheries investigated, 10 or more, separated as far apart as Gdynia and La Rochelle, the principal effects were the same namely:

1) an increase of density of stock, frequently of the order of 3-fold, ascribable to greater survival to older ages.

2) Some changes in growth-rate, but insufficient to prevent augmentation of the stock".

Whether the International Fishery Conferences of 1946 and 1947 failed or succeeded is a question for the future to show. It is, in any case, outside the terms of reference of this review. But the position of science at the end of the second conference is within the present subject, and it was clear that the conferences had, by implication, set fishery science some tasks demanding several advances, both in the field of new data and in the field of more advanced mathematical formulation.

The principal lessons for fishery science arising out of the conferences were two. First, it became clear that the general wish for an advance along the line of greatly increasing the mesh of nets, which commended itself as technically sound, and to many of the countries as the simplest and most practical measure, presented to the peoples of Holland, Belgium, and France a course that they could not expect to follow within the present generation. Their industries, both on the catching and the marketing side, depended too heavily on the populations of smaller plaice, whitings, or hake, for it to be practicable to use a mesh any larger than that of the Convention of 1946. The second lesson arose out of the first, in that the conferences had been driven to consider other measures of conservation, and after eliminating a close season or closed areas, had been left with limitation of total fishing power. Here a proposal to limit total tonnage of fishing vessels had come up against all the variety of types of vessel and of methods of fishing, which had necessitated finding a temporary and rough equivalence of conservation measures in wide variety—close season, extra large mesh, limitation of total landings, standstill in building of vessels, and limitation of total tonnage, which each country considered that it could adopt, in order to make a start.

It was clear that science must now study the relative effectiveness of different types of fishing vessel, and the Council, in the Committees of the Northern and Southern North Sea, instigated comparative trials of different types of vessels fishing against each other, thus widely extending the trials of research vessels, one fishing against another, made in earlier years.

Thus, at the Special Meeting of 1949, there were papers on size of meshes and the sizes of fish taken by them, and on the fishing capacity of complete fishing units, the vessel with its particular gear. A straight linear relation between the inner length of the mesh and the length of fish at which there is a 50 % probability of release was offered; confirmation was given of the better catches of larger fish taken by a larger mesh, and the differences in selection range of various nets were compared. Factors in the construction of the trawl were found to be important, such as that the catches of plaice seemed to be in simple proportion to the distance between otter-boards, and that each type of trawl was closely adapted to the type of bottom generally fished, and to the behaviour of the species generally sought. Two trawlers had fished together and numerical factors obtained for their relative capacity. Thus on haddock of less than 40 cm. length the ratio of their catches was 1·89 : 1; whereas for skates and rays the preponderance was the other way. On plaice a seiner on her chosen ground outfished a trawler by 2·8 : 1 on the catch per day.

Such studies are being continued.

In the meanwhile we must also note an advance in practical measures. In 1951 agreement was reached to conserve the fishery for crustacea in Scandinavian waters, as had seemed advisable from studies such as Poulsen's (1946).

Turning now to the theoretical side, arising from the position in 1945–1947, it was clear that the roughest of estimates of equivalence of different conservation measures might serve in the early stages, when the problem of the delegates at a conference table is not what they ought to agree to, but what the political and social conditions of their country's fishing industries will allow. If, however, science is to continue to lead such conferences, it was clear that really reliable and strictly fair estimates must be made of the effect on the yield of various proposals. Furthermore, no theory, so far, had shown the goal to which such deliberations might lead—a figure of 400,000 tons of demersal fish from the North Sea had been mentioned in the conferences, but it was based only on a paper of 1935 (Graham), and on another paper with hardly more data (Baerends, 1947), and was the roughest of guesses. What was still more important, the amount of fishing effort that would produce that quantity in the

most economical way, and the allowable variations of method within the total, were matters for which, in the then state of the mathematical theory, no good estimates could be worked out.

In this situation BEVERTON and HOLT developed a mathematical model on the lines of BARANOV; following a fresh start by HULME, BEVERTON, and HOLT (1947). They completed their work in MS by 1952, in time for BEVERTON to give an account of it at the Jubilee Meeting. Their main achievements can be described as two. The first was to develop a new and better fundamental differential equation; the second was extension to all or most of the second order processes, such as the various possible effects of "thinning", which had bothered the minds of fishery investigators since the inception of the subject. Throughout, in these tasks, they used the international language of formal mathematics, and they applied the theory over a wide range of data, giving worked examples.

It will be remembered that at the outset of this review, BARANOV's formulation was mentioned, and his curve shown in Figure 1. BARANOV was limited by the extent of existing data, and he introduced certain peculiarities that can nowadays be avoided. He assumed that growth in length was strictly proportional to age, which fitted data for plaice in early years, but is inherently unlikely to be true as the fish grow older. Instead of age he used length of fish, to which it is true age is related, but in an inexact way. He also carried his law of growth to infinite time, which would cause the prediction, for very much reduced fishing, of larger total yields than seem reasonable, as the shape of his curve shows. BARANOV's formulation shows how important it is to decide on a suitable law of growth.

BEVERTON and HOLT, faced with this problem, chose the growth equation of BERTALANFFY, which is in real physiological terms, with an anabolic factor depending on the "effective physiological surface" of the animal, and a katabolic factor depending on its volume or weight. The resulting curve of growth is shown in Figure 3.

The use of BERTALANFFY's law, besides having the advantage of a physiological basis, produces more reasonable results than BARANOV's, and a better fit to data on growth of plaice.

It would be beyond the scope of the present review to expound BEVERTON and HOLT's paper in detail, but in order to complete the account of work under the Council during the period, the principal equation may be given here

$$Y = FRe^{-M(t_{\varrho'}-t_{\varrho})} W_{\infty} \sum_{n=0}^{3} \frac{\Omega_n e^{-nK(t_{\varrho'}-t_0)}}{F+M+nK} \left(1-e^{-(F+M+nK)\lambda}\right)$$

where

Y = weight of annual yield in equilibrium.
F = fishing mortality coefficient (this, with the mesh, being the principal effective regulator, whether by tonnage, close season, or other method).
M = natural mortality coefficient (this being obtainable, for example, as the difference between total mortality and F).
R = number of recruits entering the area exploited by the fishery each year (being taken as constant, equal to the average over a period, for many purposes).
t_{ϱ} = age at which recruits enter the exploited area (which allows for differences in rate of migration from nurseries).
$t_{\varrho'}$ = mean age by which fish have grown large enough to be caught (by which effects of different mesh sizes can be examined).
λ = fishable life span.
K, W_{∞}, t_0 = parameters of BERTALANFFY's growth equation (which can be determined from growth data).
Ω = summation constant, having the values $+1, -3, +3, -1$, for $n = 0, 1, 2, 3$, respectively.

The equation thus enables the principal factors in rational fishing to be assessed according to the effects they would have under various schemes. An example of its form, for comparison with BARANOV's, is shown in the lower curve of Figure 1.

These authors have also, for use perhaps in the far future, given a form of the equation in which R, the number of recruits, is replaced, on a simple theory of reproductive potential, by an expression for the number of adults that generate them, which in turn can be expressed in terms of the parameters already used, with the addition of a coefficient for fecundity.

It may be thought that these authors have outstripped the development of suitable data, which is to this extent true, that only a fraction, although a substantial one, of North Sea fisheries are covered by *adequate commercial statistics, in rectangles*, and by sufficient sampling of biological "vital" statistics. It is of urgent importance that all the major fisheries of the North Sea should be so covered.

To those who have been working under the Council for most of the period under review, or for longer, it may not be surprising that the mathematical formulation of this problem contains a good many terms. The problem has always seemed exceedingly complex, even when the divergencies between data

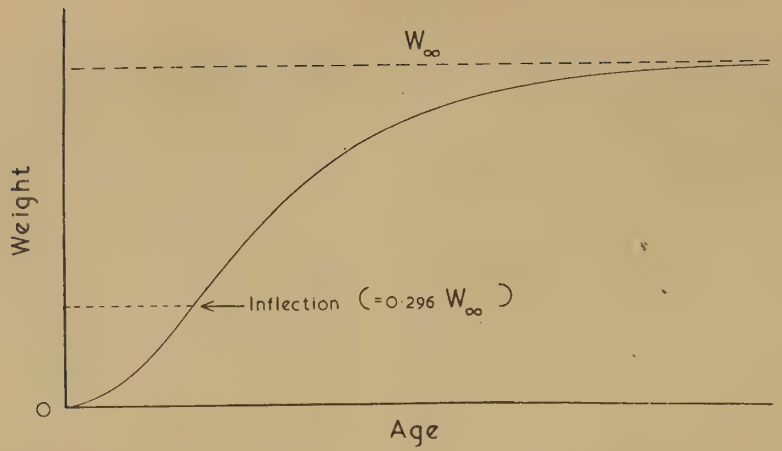

Figure 3. Bertalanffy's curve of growth.

are left out of account. On the whole, it may seem a matter for congratulation that this quarter of a century has seen this, the central problem of the Council, unravelled into a form that can, without disproportionate labour either of collection of data or of computation from them, be used to derive unbiased estimates of the average yield of the fishery under various conditions that may be proposed.

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8.

Applications to Industry and Policy.

By Aage J. C. Jensen

I attempt here a review of some principal fields of action of the International Council in relation to industry and policy. Investigations on overfishing, transplantations, and marking experiments will be reviewed by other authors. Some essential facts are no doubt missing in this report, and some have been discussed in greater detail than others which are just as significant. Thus, apart from instances included in this review, the ICES also deserves some credit for measures to the benefit of the fishery within the individual states because in many cases they have been influenced by the deliberations and recommendations of ICES.

I have gratefully to acknowledge the help of the notes received from Mr. Á. Friðriksson, M. J. le Gall, Dr. Paul M. Hansen, Dr. Hessle, Dr. W. C. Hodgson, Dr. C. E. Lucas, Mr. G. Rollefsen, Dr. Å. V. Tåning, and Mr R. S. Wimpenny, and Mr. M. Graham for a necessary abbreviation of the manuscript.

I. Applications to Industry.

Although the publications of the ICES are primarily intended for the members and for marine biologists of other parts of the world, many of them are written in such a way that they are also of interest to the practical man of the fishing industry. This is for instance true of Johan Hjort: Fluctuations in the Great Fisheries of Northern Europe, Rapp. et Proc.-Verb., Vol. XX, 1914. Among more recent publications should be mentioned especially the volumes containing the contributions from special scientific meetings, *inter alia* Vols. LXV and LXVIII, 1930: Fluctuations in the Abundance of the various Year-Classes of Food Fishes, and Vol. LXXX, 1932: The Effect upon the Stock of Fish of the Capture of undersized Fish.

In the series *Annales Biologiques* reports on fishing localities, methods and catches of the various fisheries and in many cases forecasts of the yields, are of direct practical bearing to the fisheries of the individual countries, and are usually repeated by the periodicals of each country.

The series *Bulletin Statistique* brings a comparison of the catches of the various countries within each area, calculated in actual weights landed.

One publication of the ICES is specially meant to be of help to the fishery: the *Herring Atlas*. Fisheries of the North-Eastern Atlantic (Fishing Ground, Landing Ports and Quality), 1950, under the editorship of W. C. Hodgson and with English, French and Danish texts.

Many handbooks for fishermen bring the work of the ICES in behalf of the industry. Other instances are considerable parts of many popular books on the results of the fishery investigations, f. inst. by E. S. Russell: The Overfishing Problem, Cambridge 1942, and Michael Graham: The Fish Gate, London 1943.

It may further be mentioned that considerable portions of the subjects taught at the fishery schools of Denmark, Norway and Sweden are based on the results of investigations instigated by the ICES.

a. Investigations on Fishing Methods.

During recent years investigations have been carried out on the fishing capacity of the different trawls and the Danish seine, and on the mesh-widths and their sorting of the catches. These researches were made in order to enable the biologists to judge the effects of the gears on the stocks, so that this experience could be utilized both in biological investigations, and for the purpose of procuring a basis for legislation on mesh-widths and gears[1]).

It should also be mentioned that the shapes of trawls in action have been examined by means of echo-soundings; and during recent years by means of the observations and photographs of "frog-men". These researches were carried out particularly from England and Scotland[2]).

The Norwegian fishery investigations have assisted in the development of new gears for shrimp trawling and the introduction of the purse seine in the Lofoten cod fishery.

[1]) B. B. Parrish: Fishing Capacities of Lowestoft and Aberdeen Trawls when used on Flatfish Grounds. Journ. du Cons. XVII, 2, 1951, p. 156.

[2]) A. R. Margetts: The shape of the trawl in action. Fishing News. London 1950, p. 11.

H. Wood and B. B. Parrish: Echo-sounding experiments on fishing gear in action. Journ. du Cons., XVII, 1, p. 25, 1951.

b. Aid to the Location of Fish by the Fishermen.

Biological investigations instigated by the ICES have proved the practical importance of examining the hydrographical conditions preferred by the fish: by means of a thermometer the fisherman is able to see whether there is any chance of catches. Among the results in this field may be mentioned:

(a) that cod-water (the water preferred by the cod) at Newfoundland, has a temperature of 3—5° C. (and a salinity of 33—34.5‰)[1]), at the spawning ground at the southwest of Iceland in January—April a temperature of 5—7° C.[2]);

(b) the designation of "near 2° C." and "near 4° C." as favourable for Bear Island cod fishing in the southern and western areas, respectively[3]);

(c) that the whiting gather on the spawning grounds in the western part of the Channel, when the water is coldest, between 9.5 and 11.5° C.[4]);

(d) that the herring-water on the Smalls (W. of the Channel) at 50 m. depth has temperatures below 10° C. (and less than 34.9‰ of salt)[5]);

(e) that the *Germo alalunga* in summer occurs at the surface W. of France when the temperature at 50 m. depth is above 14° C.[6]).

Those are samples of results, which also extend to other areas and other species. Hydrographical investigations combined with fishing experiments have in many instances yielded indications of fishing possibilities, e. g. in Norway[7]).

The identification of echo traces enabled herring fishermen to avoid pilchards etc. and made the echo-sounder much more valuable in the southern North Sea herring fisheries.[8]).

c. Information to the Fishermen on the Occurrence of Fish and the Establishment of new Fishing Grounds.

In the North Sea the English fishery investigations have made echo-sounder surveys with transmission of guidance to fishermen. In the Skagerak and the North Sea similar searches for herring by echo-sounder have been made by the Swedish research vessel "Skagerak", and at the Fladen Ground by the Danish research cutter "Jens Væver".

Locatings of the herring shoals on their spawning migration from the Norwegian Sea to the Norwegian coast and back again have been performed by the aid of echo-sounder and "Asdic" from the Norwegian research vessel "Michael Sars" and others since 1949, in 1950 and 1951 in cooperation with the Danish research vessel "Dana"[9]). The Norwegian fishermen were advertised of the location of the shoals by the Norwegian vessels, and in December 1951 the Faroese fishermen were informed of the herring occurring N. of the Faroes. Also Iceland, Sweden and Scotland have cooperated in these searches for herring shoals in the open Norwegian Sea. No doubt these investigations are some of the most promising results of the work of the ICES. In his note for the present report G. Rollefsen says that it does not seem unlikely that in future years the herring fishing on the Norwegian stock can be conducted throughout the year.

Reliable estimates of the abundance of the cod and the density and extension of the cod shoals at Lofoten are now being carried on from Norway by means of the echo-sounder[10]), and the fishermen every year are informed of the results of the investigations.

The Swedish Fishery Investigation Service have given guidance to fishermen of the east coast of Sweden, based on echo-sounding and fishing trials.

The Norwegian fishery investigations have located new fishing grounds of the deep sea prawn. By means of the echo-sounder new areas offering good possibilities of fishing have been charted, which during recent years resulted in a valuable prawn fishery in the northern parts of the country[11]).

The French fishings for mackerel SE. of Ireland since 1926 and for tunny with live bait at the Basque coast since 1949 were developed on the initiative of French investigators.

It should also be mentioned that the fishery investigations in many cases have resulted in suggestions to the fishermen on their participation in new fisheries: Paul M. Hansen advised Danish fishermen concerning the shark fishery at Greenland, and Dr. Tåning in 1950 suggested a Faroese herring fishery in the Norwegian Sea in connexion with the cooperative investigations from Denmark, Iceland, Norway, Scotland and Sweden.

The French fishery investigations have advised the French fishermen on the herring fishery in the North Sea, and in a number of articles the present author in 1933 discussed how a participation in the North Sea herring fishery by Danish motor cutters could be effected. Experiments were carried out in 1937

[1]) L. Beaugé in the *Revue des Travaux* de l'Office des Pêches, II, 1929, p. 202.

[2]) J. le Gall: La pêche en Islande. Rev. des Trav., III, 1930, p. 233.

[3]) A. J. Lee: The Influence of Hydrography on the Bear Island Cod Fishery. Rapp. et Proc.-Verb., Vol. CXXXI, 1952, p. 74.

[4]) F. S. Russell: Journal Mar. Biol. Assoc. Plymouth, XX, 1935 and P. Desbrosses: Rev. des Trav., XIII, 1943, p. 182.

[5]) Investigations from France.

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[7]) J. Eggvin: The movements of a cold water front. Rep. Fish. Mar. Invest., **6**, 5, 1940; **7**, 1, 1942; **7**, 6, 1944.

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[9]) B. Rasmussen and Å. V. Tåning in Ann. Biol. VIII (in the press).

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and 1938 on the initiative of the fishery union for west Jutland, and the commercial fishery started in 1946.

d. Forecasts of the Yields of Fishery.

Forecasting of the yields of fishery has been in rapid growth during the latest decades, more particularly because the investigations of the ICES on many species of fish have accumulated a material that is sufficiently large for an examination of the factors that determine the fluctuations of the yields of the fisheries.

In many cases the frequency of the individual year-classes characterize the fish populations throughout several years, which was demonstrated by the researches of the ICES after this fact had been established by JOHAN HJORT in the case of the Norwegian herring (Rapp. et Proc.-Verb., XX, 1914). Discussions of these investigations at all later meetings of the ICES resulted in a uniform treatment of the material in the different countries. In Rapp. et Proc.-Verb. LXV and LXVIII, 1930, a survey was given of our knowledge at that time of these fluctuations in the frequency of the year-classes.

When the age composition of a species of fish in the catches of some fishery has been followed throughout a series of years, it is possible to calculate the average distribution of the fish captured and to forecast the yield of the fishery during the next year from the deviation of the said years from the normal distribution. As an instance may be described the forecasts for the East Anglian herring fishery.

The first detailed investigation into the mechanics of the East Anglian herring fishery began in 1921, and was influenced by the pioneer work on herring research by EINAR LEA under the Council. After some years of observation of the annual changes in the fishery, an attempt was made to put to practical use the biological knowledge gained, and the result of this was the publication of the first fishery forecast in 1929.

Fish first enter the autumn shoals at the age of 3 years and the approximate span of life of these herrings is 12 years. As in the Norwegian herring referred to above, fluctuations affect the stock during the whole period of the adult life of the herring, so that a very strong 3-year-old year-class remains strong and a poor 3-year-old year-class remains poor until they disappear at the age of 12 years. Herrings of any year-class show the same biometrical characteristics year after year.

On the average, there has been found to be an increase in numbers of 135% between the ages of 3 and 4, and after 5 years of age there is a decrease, the rate of which increases with age.

This mortality rate is approximately 35.4% between the ages of 5 and 6 and 68.6% from 9 to 10 years of age. It is clear, therefore, that if the age composition of the shoals is known for the year x, the age composition for the year x + 1 can be calculated, and from the expected age, the expected length can also be found.

In East Anglia, the date of the full moon has a big effect on the characteristics of the herring season, so, in forecasting, this must also be considered. It has been found that lunar effect varies considerably with the date of the October moon, the best fishings resulting from full moons occurring after 11. October. A "peak" fishing is usually associated with the full moon except when the latter occurs during the first week of the month, and an early fishing can be expected when:

1) there is a large stock of 3 and 4-year-old herrings,
2) the full moon occurs after the first week of October,
3) there has been a south-westerly wind in September, which is known to accelerate the migration from north to south.

The forecasting of a late or early start of the fishery is of considerable importance to the Scottish fishermen who dislike leaving their home fishing before it is absolutely necessary.

In a similar way, i. e. basing on the age composition of the catches, forecasts have appeared for other herring fisheries of the North Sea and the Channel: from Belgium by M. GILIS, from France since 1928 by J. LE GALL, since 1945 by J. ANCELLIN, from Germany and Scotland, and further for the Swedish herring fishery in the Baltic by the Swedish investigations.

The yield of the cod fishery can be foretold in a similar way, and during recent years such forecasts have appeared for the Lofoten cod fishery[1]).

For cod and plaice fisheries within the Skaw annual Danish forecasts are based on examinations of the amounts of about six-month-old and older fish.

Investigations on the causes of fluctuations in the yields of fishery have often shown that hydrographical conditions play a very prominent part.

The forecasts for the Danish silver-eel fishery in the Belt Sea, the Sound and the Limfjord are based on the summer temperature: the higher the temperature, the more yellow eels will turn into silver-eels[2]).

The yield of the pelagic fishery for mackerel in the Skagerak and the northern Kattegat may be foretold from the conditions of wind and surface salinity, because strong easterly winds during the preceding period will press the water out through the Skagerak (which results in a low salinity) and because a rapid outflow is followed by a rapid inflow, which carries the mackerel along[3]).

[1]) G. ROLLEFSEN: The spawning zone in cod otoliths and prognosis of the stock. Fiskeridirekt. Skr. IV, 11, 1935. Idem: The stock of skrei in 1939. Ibid., VI, 4, 1940.

[2]) J. P. JACOBSEN and A. C. JOHANSEN: On the causes of the fluctuations in the yield of some of your fisheries II. The Eel-Fishery. Medd. Komm., Ser. Fisk. VI, a, 1922, and AAGE J. C. JENSEN: The Danish forecasts of the yield of some fisheries. Rapp. et Proc.-Verb. Vol. CIX, 3, p. 75.

[3]) A. C. JOHANSEN: On the influence of the currents upon the frequency of the mackerel in the Kattegat and

No doubt more forecasts of yields of fishery during the next years may be based on the results presented at a special meeting of ICES in 1951.

II. Applications to Policy.

From the start the second main object of the ICES was to procure a scientific basis of international measures that intend to bring the fishermen heavier yields by rationalizing the exploitation of the stocks of fish. However, the proceedings of the ICES have also come to exercise an ever increasing influence on the endeavours of the individual countries to improve the yields of the fishermen.

When careful investigations and discussions in the ICES seem to warrant advice to the governments this is passed to them through the Danish Foreign Office.

In several cases such communications have led to international conventions. Some of them will be dealt with in the following.

It is of course of very great importance that an institution with the authority of the ICES should freely point out the measures that should be taken in order to improve the yields of the fisheries, even when they cannot be carried out. Time will no doubt show that the ICES is in the right and then such proposals will be passed. But it should be added that the economic conditions of the fisheries are so complicated that the effects of great changes cannot be foretold with certainty, and so it is no doubt better to carry through small changes at a time.

The complicated nature of things, as far as the demonstration or passing of rational measures are concerned, appears from the fact that though in the course of a given time and with the same gear an increase in the yield of the fishery may be obtained either by protecting the undersized fish or by limiting the fishery, the former measure runs up against the practical difficulty that many different species of fish are taken at the same time in a trawl and that a mesh-width which for instance gives a really rational exploitation of the stock of plaice is so big that practically no soles will be taken in the gear. On the other hand a limitation of the total fishing intensity would come up against the practical impossibility of employing the boats and the fishermen that might thus be excluded from the fishery.

On the part of the industry, however, there is an ever increasing acknowledgement of the practical value of the endeavours of the ICES. A very convincing instance of this is the fact that the "English distant water trawlers voluntarily abstained from fishing the North Sea in 1946, whereas in 1919 they had scooped up the war time accumulation" (communicated by Mr. Wimpenny). There is no doubt whatever that this abstention paid a dividend, because it delayed the depletion of the stocks after the war; but the development showed, and no wonder, that this measure alone failed to prevent the depletion.

The necessity of measures on the part of public authorities (in many cases in the form of international conventions because several countries are working the same fishing grounds) is of course particularly conspicuous when the harmful effects of the fishery on the stock are big enough to endanger the profitableness of the fishery. From the beginning of the ICES its efforts were mainly directed against such cases. Its investigations have shown, however, that in many cases it is possible to increase the yield per fishing unit to a considerable degree by rational measures even though the fishery has not affected the stock to such an extent, that the fishery is endangered by over-exploitation.

This is for instance true of the sole fishery in the North Sea where favourable natural conditions during recent years have increased the stock and, consequently, the yield of the fishery in spite of a very irrational fishing of the stocks as a whole, and of the cod fishery in the Baltic, where the fishery in its present form can also be proved to be irrational. It is a common misconception that a profitable fishery or a rise in the yield mean that everything is all right. There is hardly any doubt that the work of the ICES to an increasing degree will be directed towards showing how an optimal yield per fishing unit and optimal catches can be obtained notwithstanding natural fluctuations in the size of the stock.

a. Flatfish in the Baltic. — The Convention of 1929.

As early as 1902 one of the 3 committees appointed by the ICES (Committee C) got the task of examining whether the stock of the Baltic was being worked too intensely and of finding out which measures could prevent eventual damage. The stock was examined in many different ways, and the first result of the work was the procuring of material, which was sufficient for judging of the adequacy of international conventions aiming at a rational exploitation of the stocks. In September 1928 a meeting of representatives from Denmark, Germany, Poland, Danzig and Sweden took place in Berlin, and its discussions on the protection of the stocks of plaice and flounder in the western and southern Baltic resulted in the convention of 17th December 1929 making regulations for the fishery of plaice and flounder in the Baltic. These regulations were based on international investigations on the Baltic stock of flatfishes and the influence of the fishery thereupon.

However, the international minimum sizes introduced by this convention were too low to bring about a real improvement in the yield of the fishery, and in 1934 the Baltic Committee of the ICES recommended to raise the international minimum size for plaice in part of the area. In a meeting of experts

adjacent parts of the Skagerak. Medd. Komm., Ser. Fisk., VII, 8, 1925, and Aage J. C. Jensen: Utsikterne för makrillfisket i Kattegat-Skagerak. Ny Svensk Fiskeritidsskr., 1933, p. 128.

held by the ICES in December 1935 it was recommended that amongst other things the size limit for the flounder should be increased by 1 cm. (Rapp. et Proc.-Verb., C, Pt. 2, 1936, p. 35); the 1936 meeting recommended to raise the size limit for the plaice to 24 cm. The ICES recommended these proposals to the favourable consideration of the governments concerned (Rapp. et Proc.-Verb., C, Pt. 1, 1936, p. 21).

b. The Fisheries in the Skagerak, the Kattegat and the Belt Sea. — The Convention of 1937.

During the meetings of the ICES it has repeatedly been demonstrated that the plaice fishery since about 1910 and other fisheries during recent years have been pursued in an irrational manner. Suffice it to mention here that in 1929 it was resolved to recommend a common minimum size for plaice in Denmark, Norway and Sweden and a prohibition of trawling from steamers and large motor vessels belonging to Denmark, Norway and Sweden on the nursery grounds of the plaice in the western Kattegat.

As a consequence of the investigations (see Rapp. et Proc.-Verb., LXXI, 1931) a convention between Denmark, Norway and Sweden in September 1937 agreed upon a minimum size limit of 260 mm. for the plaice and 230 mm. for the dab in the Skagerak, the Kattegat and the Sound. Since 1938 Sweden has a minimum size of 270 mm., Norway one of 290 mm. for the plaice.

c. The North Sea and adjacent Waters and Northern Seas. — The London Convention of 1946.

The comprehensive investigations resulting from the collaboration in the ICES, ever since its start in 1902, dealing with the question which stocks of fish had been worked in an uneconomic way, immediately after the first world war led to a proposal from the ICES to introduce really large-scale measures for the protection of the stock of plaice in the North Sea. The commercial improvement of the stock resulting from the partial protection during the war was a practical confirmation of the results achieved by the investigations of the fishery biologists, and it should therefore have been easy to introduce rational measures. However, this could not be carried through because the industries could not accept the proposals. No doubt, however, the marked exhaustion of the stock during the years between the wars, its improvement through the partial protection during the second world war, and the renewed impoverishment after this war, have convinced a very great part of the men of the industry.

The principal measure proposed in 1920 was the closing of some young plaice grounds. The changes in the stock during the last war have undoubtedly proved that protection of the young plaice would give the fishery a great economic gain through heavier yields per fishing unit[1]). However in later years the ICES has chosen to advocate only a rise of the minimum size of fish and meshes and a limitation of the total fishing intensity, which does not mean so great a revolution to the fishery as the closing of a large area.

From the discussions by the ICES on these questions during the last 25 years, it may be mentioned that in 1930 the view was advanced in recommendations "that the question of saving round fish just below the marketable size by means of enlarged cod-end meshes was so far advanced that it might profitably be discussed with the fishing industry in each country." (Rapp. et Proc.-Verb., LXVI, 1930, p. 30).

A special meeting of the Council in 1932 on "The Effect upon the Stock of Fish of the Capture of Undersized Fish" opened the way to the general acceptance of mesh and fish size regulation, by concluding that it was worth while to save pre-recruit fish and that thinning out did not result in a greater catch (Rapp. et Proc.-Verb., LXXX, 1932).

In 1934 the special meeting on "Size-Limits for Fish and Regulation of the Meshes of Fishing Nets" (Rapp. et Proc.-Verb., XC, 1934) provided basic information for the Meshes of Fishing Nets Convention, signed in London in 1937. This limited the mesh to 105 mm. in the north-eastern area and 70 mm. in the North Sea and adjacent areas, and gave minimum sizes for the most important species of food fishes.

The subsequent Overfishing Convention of 1946 obtained agreement to increase these meshes to 110 (in a wider area) and 80 mm. respectively, and raised the minimum size at which fish should be taken.

The convention has been ratified by almost all the countries that have signed, and is expected to be put to force in the near future.

In accordance with the recommendations of the ICES minimum sizes of cod-end meshes of trawls, seines and other nets, and minimum sizes of demersal fish landed in Great Britain were introduced in 1933 and 1938 and revised in 1948 according to the International Convention of 1946.

Denmark, Sweden and Norway have higher minimum sizes than those of the convention for some species of fish, but no minimum sizes for others. Some countries have introduced measures to prevent irrational fishing, e. g. prohibition of landing ripe plaice (Denmark) and of various kinds of fishery in the coastal waters; in Scotland such legislation, also on the size of the boats used in these inshore waters, existed long before the establishment of the ICES, but some of the later alterations have been influenced by the deliberations of the ICES.

d. Crustaceans. — The Convention of 1951.

The stocks of Norway lobster, common lobster and deep sea prawn in the Skagerak and the northern Kattegat are exploited from Denmark, Norway and

[1]) Aage J. C. Jensen: The Stocks of Plaice in the North Sea and the Transition Area during the War. Rapp. et Proc.-Verb., CXXII, 5, 1948.

Sweden. Investigations had demonstrated a serious decrease of the value of the prawn fishery, and so the ICES in 1938 and 1939 proposed that the countries concerned should agree on measures of protection. After the war the examinations of the stock and the effects of various measures taken were resumed, and in 1947 a sub-committee, which had been appointed to look over the results, concluded that as a decrease in the stock of prawn had been observed in certain places the experts regarded immediate protection as necessary for the international waters in the Skagerak and the Kattegat. It proposed measures for mesh-size, for the method of closing the cod-end, and, for the common lobster and Norway lobster, minimum sizes.

The Consultative Committee found that these findings of the Sub-Committee were of substantial importance and recommended that the Council should ask the Danish Foreign Office to draw the attention of the countries concerned to these results.

Accordingly, a meeting was held in Oslo in February 1951 by representatives from Denmark, Norway and Sweden, consisting of government officials, biologists and fishery professionals, and proposals for an agreement were accepted fixing the said minimum width of the mesh of cod-ends and the minimum size for the Norway lobster, while "it was considered desirable that the size limit of the common lobster should be raised, but the fishermen did not hold the present moment opportune for such a raise". Further that "standing committees of representatives of the three countries should be set up for the co-ordination of research into these crustaceans, and for making proposals as to further protective measures." (Rapp. et Proc.-Verb., CXXX, I, p. 20).

The individual countries had already introduced minimum size limits for the crustaceans and regulations of the gears that were at least as strict as those of the convention, but the fixing of the rules in the convention is an advantage.

e. Enquiries on Salmon and Sea Trout in the Sea.

These fisheries have been discussed repeatedly in the Salmon and Trout Committee and other committees of the ICES. By way of example may be mentioned the enunciation from 1932 "that in order to protect and improve the stock of salmon an effective size limit for the salmon in the Baltic should be introduced" and that the possibility of cooperation between the Baltic countries to improve the propagation of the salmon in the Baltic proper should be considered.

The ICES brought this recommendation to the notice of the governments for their consideration (Rapp. et Proc.-Verb., LXXXI, 1932).

In 1950 a sub-committee was appointed for the purpose of considering whether a protection of salmon in the sea in offshore waters is required. At the meeting of 1951 it was reported that more effective statistics and various biological investigations on the salmon in the open sea were necessary.

Many regulations of both the salmon and the trout fishery have been introduced in various countries in the course of time.

f. Enquiries on the Fishing of small Herring, Sprat and other young Fish.

In countries where many young herring have been taken by the fishery the fishermen have often feared that this fishery would damage the stock and hence the fishing of adult herring. After discussions during the meetings and investigations to this effect the ICES, however, advanced the opinion that "the present method, and present extent, of capture of young herrings do not involve appreciable damage to the stock, nor (consequently) to the yield of the fisheries" (Rapp. et Proc.-Verb., LXXXI, 1932, p. 28.)

In accordance with this the Norwegian fishery science "could not recommend the introduction of closed seasons or total protection for small herring, when the fear was expressed that substantial small herring fishing in the Norwegian fjords would ruin the stock of herring" (manuscript report from Mr. Rollefsen for Norway).

Since the end of the thirties an extensive fishery for fish meal factories, food for trout ponds and mink and fox farms has developed in the Skagerak and the inner Danish waters. This fishery more especially takes small whiting, small herring and small sprat. From an investigation on the number of small herring fished H. Blegvad in 1945 (Rep. Dan. Biol. Stat., No. 48) concluded that this fishery must be a serious menace to the fishery for adult herring in the southern Kattegat and the Belt Sea. On the basis of extensive analyses of the catches and calculations from the natural decrease in the numbers of fish from the young age-groups fished for fish meal etc. until they reached the adult stage the present author has found that the fishery for young fish in the southern Kattegat and the Belt Sea reduced the yields of adult herring of some of the local races to a perceptible degree, by up to about 10%, but that the fishery for sprat for canning (mostly adult fish) was reduced both in the Skagerak, the Kattegat and the Belt Sea by as much as 20%, on some cases undoubtedly even more, and he suggests that measures be taken to diminish these harmful effects (Aage J. C. Jensen in Medd. Danmarks Fisk.- og Havunders., N. S., Bd. 1, 1952).

Especially the Dutch "Puff" fishery, but also the German "Gammel" fishery, have taken considerable amounts of young flatfish, particularly plaice, in the southern North Sea. The effects of this have been examined by the ICES, especially through the comprehensive investigations of J. Tesch. Also the destruction of plaice below the commercial size by trawl fisheries in the coastal areas of the southeastern North Sea have been examined, *i. a.* by the present author. On the basis of the results of these investigations the ICES advanced the opinion "that an unrestricted fishery, especially on the so-called Nursery Grounds, is a danger to the maintenance of the market-

able stock and is likely to be followed by a diminution of the yield." (Rapp. et Proc.-Verb., LXXXI, 1932).

The above-mentioned investigations on the Danish-Swedish fishings for fish meal have shown that also the yields of adult whiting and cod must be damaged perceptibly. As regards the whiting it was believed that the introduction of the measures of the London convention would limit the damage considerably, and for the cod a closed area has been proposed.

g. Closure of the Moray Firth.

The Moray Firth has been closed against trawling since 1892. In 1925 the ICES appointed a committee to inquire into the effects of trawling in the firth; it recommended partial closure for the particular purpose of conserving spawning plaice.

h. Closure of the Faxa Bay at Iceland.

The Icelandic fishery investigations and public administration have proposed the closing of part of the Faxa Bay against trawling. A sub-committee appointed by the ICES for the purpose of examining this question has made a report to the effect that this closing would be of advantage to the fishery (Å. V. Tåning (as editor): Rapp. et Proc.-Verb., CXX, 1947).

In 1952 Iceland has extended its territorial waters, including the Faxa Bay, which has been closed for trawling.

i. Closure of a small Area N. of the Faroes against Fishing with Lines or other Gears during Part of the Year.

This question was examined by a sub-committee of the ICES, and on the basis of these investigations the problem was discussed at the meetings of the ICES. In 1949 the closure was adopted by the Faroese fishermen through the "Lagting" of the Isles, but the negociations have not yet come to an end.

j. Rational Exploitation of the Stock of Whales.

The Whaling Committee of the ICES has discussed the development of the whaling, especially in the Antarctic, and the knowledge of its effects on the stock. It has recommended a limitation of the quantity caught and other measures. After the setting-up of the International Whaling Commission it was decided in 1950 to suspend the regular meetings of the Whaling Committee of the ICES, but to hold meetings if it appeared desirable for the purpose of discussing matters connected with whales and whaling.

k. Other Measures.

Among the many other measures introduced in the various countries cooperating in the ICES only a few will be mentioned here. Minimum sizes higher than those introduced by the conventions, or extending to other species, are in force in many countries. In Norway closed seasons have been enforced for halibut, plaice and sprat, and also minimum sizes for certain species and mesh regulations have been introduced in accordance with scientific findings. By decree of the French government two coastal areas at Sables d'Olonne and La Rochelle have been protected as reservations for the immature animals. In various countries the fishery biologists cooperating with the ICES are consulted by the ministries on questions concerning regulations of the fishery.

III. Cooperation with other International Organisations.

The ICES has always preserved a close contact with other international organisations working on the same lines, e. g. with FAO: representatives of both councils have been invited to attend the meetings of the other, and common meetings have been arranged for the purpose of discussing various questions concerning the benefit of the industry. This is also true of the International Commission for the Northwest Atlantic Fisheries, which was established in 1949, and carries out similar investigations within this area and, within certain limits, has the power of making regulations. Representatives of the fishery and sea investigations of Canada and the United States have attended the meetings of the ICES for many years.

It appears from this brief survey that the ICES in many fields has been able to act up to its programme, the benefit of the fishery. It has been pointed out that during the years to come the ICES will no doubt be able to extend its help on the basis of the knowledge acquired and the methods of investigation developed during the past 50 years.